# A TEXT-BOOK

OF

# CLINICAL ANATOMY

FOR

STUDENTS AND PRACTITIONERS

BY

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# PREFACE TO THE SECOND EDITION.

I desire to thank the teachers of anatomy and the general practitioner for their encouragement and the warm reception given to the first edition of this book. As stated in the preface to the latter it is intended as a bridge between the anatomy usually taught in the first and second years and the clinical work of the last two years of a medical course.

I am gratified that interest has been awakened in the teaching of surface and topographic anatomy as applied to the daily practice of both medicine and surgery. The text has been thoroughly revised and a number of illustrations added. I wish to thank the publishers for their uniform courtesy.

DANIEL N. EISENDRATH.

# PREFACE.

MANY changes have taken place in the teaching of anatomy during the past twenty years. The rapid development of the various branches of practical medicine and surgery has necessitated a most thorough preparation in the fundamental subjects, such as anatomy, physiology, chemistry, and pathology. In the majority of our medical schools descriptive anatomy accompanied by dissections is taught during the first two years, and then the student feels that he may consider anatomy a closed chapter. In but few of the colleges is he taught to take a perspective view, or, in other words, to study Regional or Topographic Anatomy. He has spent many hours in the memorizing of nerves, arteries, veins, and the description of viscera, but he is unable to apply this knowledge to clinical work.

The primary object of this book is to serve as a bridge for both practitioner and student from the descriptive anatomy, as it is usually taught in the first two years of a medical course, to its daily application at the bedside, in the clinic, or in the operating room.

The term "CLINICAL ANATOMY" seemed to be the most appropriate one to use to express the larger field which the subject covers. The term was first employed in this sense by Dr. A. D. Bevan, to convey the fact that clinical anatomy is anatomical knowledge as applied to every branch of clinical work—*i. e.*, not only medicine and surgery in the narrower sense, but all the specialties.

In teaching this subject to third year medical students the author felt the need of a text-book which should cover not only the surgical but also the medical portion of the subject, and he hopes that the work will not be found to have been written from the standpoint of the surgeon alone.

An especial attempt has been made to encourage both practitioners and students to examine the normal human body during life, to palpate and outline structures, and to study the relations of nerves, vessels, viscera, etc., the knowledge of whose position is indispensable to every one engaged in the practice of medicine.

It has not been deemed advisable to take up the details of anatomy,

since this book, if used as a text-book, is intended for students who have finished a course such as is covered by the standard text-books of anatomy.

In his course on Clinical Anatomy the author insists upon surface anatomy as of great practical value to the student, in order that he may become accustomed to relations as found in practice.

The majority of the illustrations in this work are original. Many of the surface outlines were marked upon a normal artist's model and then photographed. Sections of joints and those of the trunk at different levels were made from formalinized cadavers, with the kind cooperation of Professor William T. Eckley, to whom the author desires to express his thanks. In order to render the photographs desirable for reproduction, it was necessary in most cases to retouch them.

The chapter upon the Eye was written by Dr. Mortimer Frank, for whose valuable assistance in the preparation of illustrations the author also desires to express appreciation, as well as to Drs. W. E. Quine and D. A. K. Steele for their encouragement. Many of the illustrations of fractures were made from $x$-ray pictures kindly lent by Mr. W. C. Fuchs. Dr. J. S. Brown has prepared the index.

DANIEL N. EISENDRATH.

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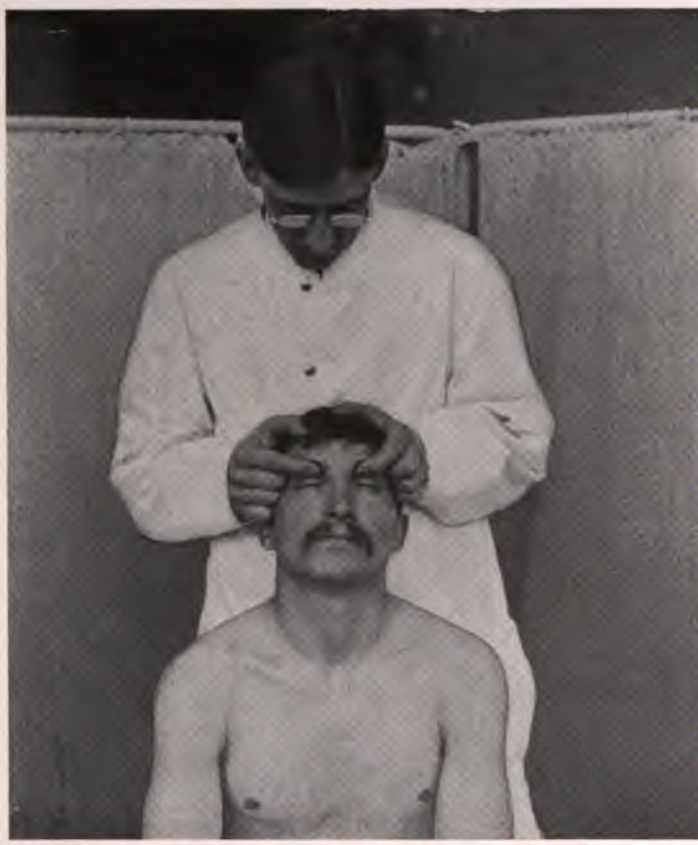

Fig. 1.—Method of making pressure upon the supraorbital nerves. To be emplc in making a diagnosis of certain intracranial affections of supraorbital neuralgia. ' examiner should stand behind the patient's head, and make pressure with the in finger of each hand over the supraorbital notches.

# CLINICAL ANATOMY.

## THE HEAD.

**Examination of the Cranium of the Living Adult.**—1. Pick up the skin of the scalp between the fingers, in the frontal and lower portions of the temporal regions (non-hairy portion of the scalp), and note how much thinner and more elastic it is than that over the skull (hairy portion).

2. Slide the scalp upon the underlying skull and observe the movements of the scalp caused by the contractions of the occipitofrontalis muscle.

3. Palpate the bony prominence situated in the median line on a level with the upper margins of the orbit and just above the root of the nose. This is the glabella.

4. Passing outward from the glabella can be felt the supra-orbital ridges. They correspond to the position of the frontal sinuses, and their lower boundary is formed by the supra-orbital margin. At the junction of the inner and middle thirds feel the notch through which the supra-orbital nerve emerges. Pressure upon it causes a dull pain (Fig. 1).

5. At the outer end of each supra-orbital margin palpate the external angular process of the frontal bone.

6. Just above the supra-orbital ridges, and separated from them by a slight depression, note the two more or less prominent frontal eminences. They are of no clinical importance.

7. Palpate the zygoma along its entire extent from the external angular process to the ear. Just in front of the latter one can feel the pulsations of the superficial temporal artery.

8. Palpate the temporal ridge over the side of the skull from the external angular process to its termination behind the ear in the mastoid process. This posterior end is to be felt as a slight depression.

9. Feel the depression on each side of the skull between the temporal ridges and the zygoma; it is the temporal fossa, and in it can be plainly felt during mastication the movements of the temporal muscle. In many, beyond the age of forty, a tortuous anterior branch of the temporal

artery which passes obliquely forward across the temporal region is visible here.

10. Palpate the mastoid process from its base to its tip. Passing almost horizontally backward from its base one can feel the superior curved line of the occipital bone as a ridge which terminates behind in the median line of the skull at the inion or external occipital protuberance. At about its middle a notch can be felt through which the great occipital nerve passes upward to the skull. Pressure upon this causes a dull pain.

11. In many adult skulls one can feel a depression in the median line about three inches above the inion, or occipital protuberance, which is called the lambda. It corresponds to the position of the lesser fontanelle. On either side of it, and slightly forward, one can palpate two bony prominences—the parietal eminences.

**Examination of the Cranium of the Living Infant.**—1. The large and small fontanelles are to be felt as depressions (see Fig. 2) which pulsate. These depressions can be felt up to the end of the second year at the anterior and posterior ends, respectively, of the suture (sagittal) between the two parietal bones. They bulge somewhat, as the child cries, owing to the increase of intracranial pressure.

2. Palpate the various superficial sutures between the cranial bones—

The sagittal between the two parietals;

The coronal between the two parietals and the frontal;

And the lambdoidal between the two parietal and the occipital bones.

Note how in infants the bones slide upon each other and also observe their great elasticity, owing to which they are seldom broken.

3. Note the more rounded form of the infant's as compared with the more oblong, dolichocephalic skull of the adult (see Fig. 2).

4. Observe the lack of development of the supra-orbital ridges (frontal sinuses) and mastoid processes.

## General Topography of the Cranium and its Coverings.

The head is divided into the cranium, or skull proper, and the face. The cranium, or skull proper, embraces all that portion of the head which lies above a line passing through the eyebrows in front, the external auditory meati laterally, and the occiput behind. The skin covering it is called the scalp, and is divided into a hairy and a non-hairy portion (temporal and frontal regions).

The bony skull contains the brain and its membranes, and consists

**Fig. 2.**—View of skull of adult and child (at full term) from above. In the adult skull the dotted line in the middle shows the location of the longitudinal sinus and of the fissure between the two hemispheres. On the right side are seen the convolutions in which are situated the principal motor areas. Those of the leg are nearest to the median line, *i. e.*, highest; those of the arm next, and those of the face lowest. These are all situated in the ascending frontal (A F) and ascending parietal (A P) convolutions. The fissure of Rolando (F R) is seen running downward and forward between these two convolutions. On the left side of the skull the method of determining the position of the fissure of Rolando without a special instrument is shown. The mark × is a point midway between the glabella and inion. The fissure is found by taking a point half an inch behind × and measuring an angle of 67 degrees running downward and forward. In the view of the child's skull are seen two fontanelles, the anterior or larger at L, the smaller or posterior at F. S, sagittal suture. C.P., most frequent location of cephalhematomata (on the parietal bones).

of a more convex or arching portion, the vault or vertex or skull cap, and a horizontal portion, the base. The close relation between the scalp, bony skull, and structures of the interior of the cranium can be best understood by a reference to figure 3.

The scalp is seen to consist of three layers: (1) The cutaneo-aponeurotic, or outermost, is composed of the skin of the scalp, the subcutaneous connective tissue, and the aponeurosis of the occipitofrontalis; (2) the second, or middle layer (subaponeurotic), is made up of loose areolar tissue which binds the outer layer to the (3) third, or innermost layer,—the pericranium,—which is an almost translucent, thin membrane, more or less firmly attached to the outer table of the skull.

These three layers contain a rich network of blood-vessels, nerves, and lymphatics, principally situated between the aponeurosis and skin. A great many branches of these vessels and nerves penetrate the skull and communicate with those of the interior, so that hundreds of channels exist for infection to be carried to the meninges and brain. Similarly, pain due to intracranial affections (tumor, abscess, etc.) is often referred to the corresponding point on the scalp, and is of great assistance in localization.

The cutaneo-aponeurotic, or outermost, layer consists of thick, inelastic skin, firmly attached to the aponeurosis of the occipitofrontalis by a closely woven network of connective tissue which binds these three layers so firmly that they can be considered as one layer, the skin moving with the aponeurosis. In the temporal and frontal regions this layer is far more elastic and more closely resembles that of the face, permitting of greater swelling than upon the hairy portion of the scalp. Erysipelas of the scalp and similar infective processes are difficult to recognize on account of the fact that but little swelling can take place in this cutaneo-aponeurotic layer of the scalp. The connective tissue of the scalp is arranged in bundles which run more or less vertically inward from the skin to the aponeurosis. Between these lie small masses of fat, hair, and many sebaceous glands, the hairs extending as far as the aponeurosis. The blood-vessels, nerves, and lymphatics lie chiefly in this layer, hence infection and sloughing of flaps are rare after scalp wounds, owing to the rich anastomoses. Hemorrhage from wounds of the scalp is more difficult to control than elsewhere, on account of the rigidity of the connective tissue, keeping the vessels open and permitting them to retract so that ordinary ligation will often not suffice, transfixion of an artery being necessary.

The principal vessels and nerves which supply the scalp are seen in figure 5. They are:

1. Anterior........Supratrochlear nerve and frontal artery.
Supra-orbital nerve and artery.
2. Lateral.........In front of ear, auriculotemporal nerve and superficial temporal artery.
Behind ear, (*a*) small occipital nerve and posterior auricular artery. (*b*) Great occipital nerve and occipital artery.

The frontal artery nourishes the pedicle of a rhinoplastic flap, and the temporal artery serves as a guide to the anesthetist.

From the above it will be seen that the greater portion of the scalp is supplied with sensation by the fifth nerve, which also supplies the dura, so that pain due to inflammation or pressure upon the latter is often referred to the scalp.

The *lymphatics* (see Fig. 4) of the anterior half of the scalp empty into glands situated just beneath the skin of the parotid region and into those inside of the parotid gland itself. Those of the posterior half drain into glands lying behind the ear (posterior auricular) and along the superior curved line of the occipital bone. One is frequently consulted for enlarged glands in children, lying just in front of and behind the ear, for whose cause one should always examine the corresponding portion of the scalp.

The *veins* of the scalp accompany the arteries and empty into the veins of the face and neck, especially the external jugular. These surface veins all communicate with the sinuses of the dura mater, and indirectly with those of the pia-arachnoid, by means of innumerable small emissary veins which pass through the skull. In addition there are a number of larger ones. These are (see Fig. 7):

1. One between the frontal vein and longitudinal sinus.

2. One between the nasal vein and cavernous sinus, through the ophthalmic veins.

3. One between the posterior auricular veins and the lateral sinus (mastoid).

4. One between the occipital veins and lateral sinus.

Not infrequently infection will spread from the skin of either the face or scalp and cause a thrombophlebitis of the subcutaneous veins. This, by direct continuity, will spread through these emissary veins into the interior of the skull, causing a thrombosis of the endocranial sinuses with resultant pyemic conditions, or it may cause a septic meningitis.

Beneath the cutaneo-aponeurotic layer is the subaponeurotic layer. This is a mere loose network of connective tissue binding the aponeurosis to the external covering of the skull or pericranium. On account of th

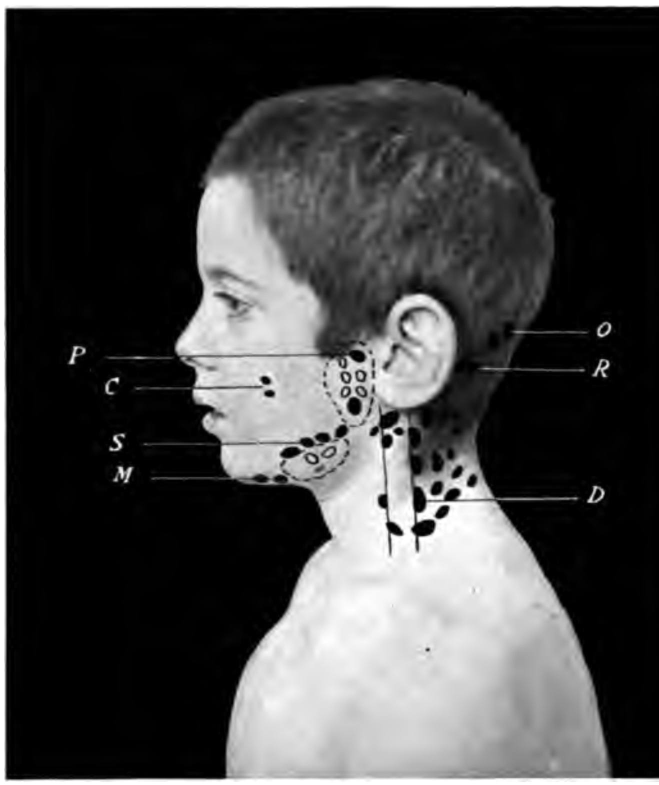


Fig. 4.—Lymph-nodes of face and neck. The deep nodes are shown as black solid areas; the superficial as a black circle: *P*, Lymph-nodes lying within capsule of parotid gland; those lying upon the parotid and beneath the skin (preauricular nodes) are shown as black circles. *C*, Lymph-nodes occasionally present in substance of cheek. *S*, Submaxillary nodes lying within capsule of gland; those lying between the capsule and skin are shown as black circles. *M*, Submental nodes. *O*, Occipital nodes. *R*, Post-auricular or mastoid nodes. *D*, Deep cervical nodes lying along the anterior and posterior borders of the sterno-cleido-mastoid muscle and internal jugular vein, communicating with the nodes of the posterior triangle.

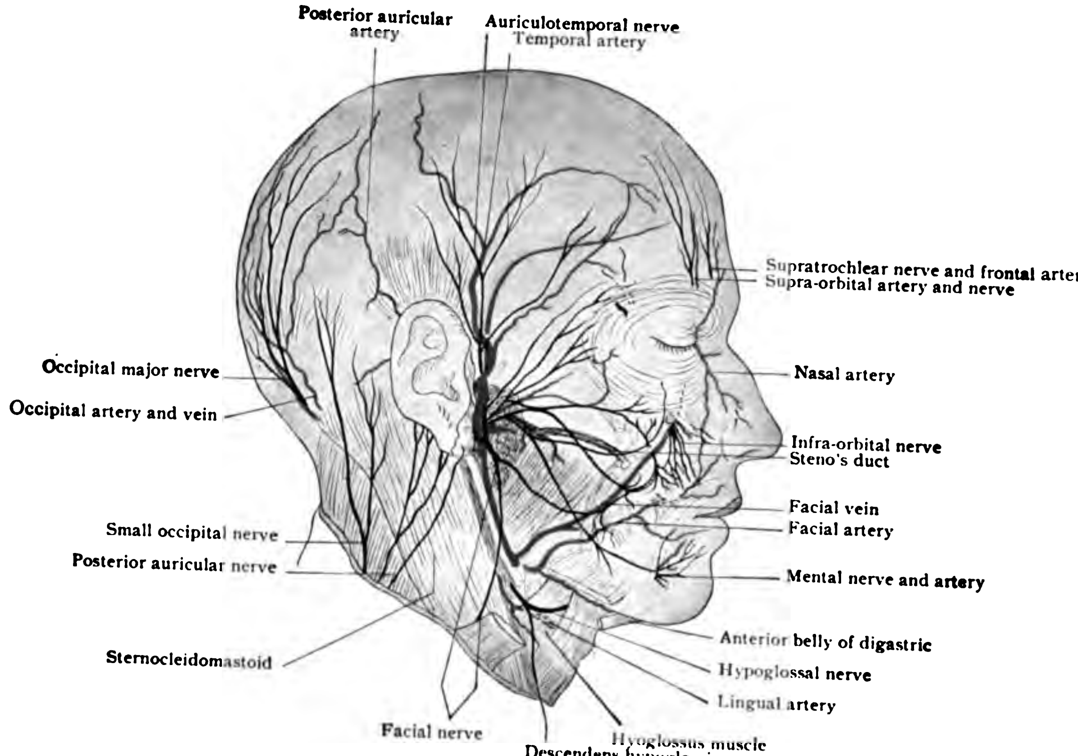


**Fig. 5.—Lateral view of head and face, showing vessels and nerves, parotid gland, and Steno's duct (after Henle).**

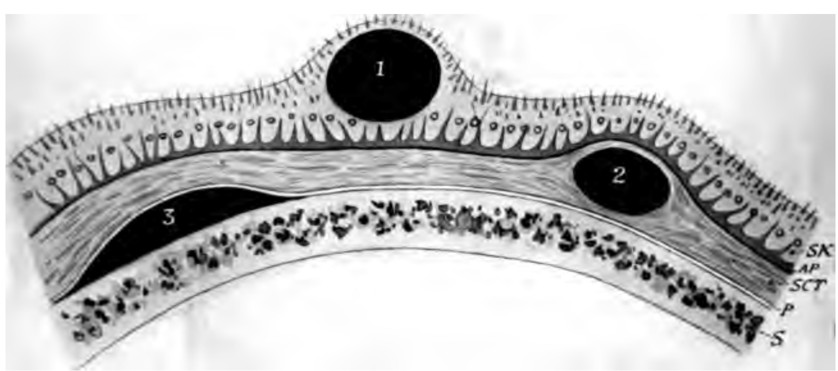


Fig. 6.—Location of various hemorrhages in the scalp: *SK* and *AP* represent the cutaneo-aponeurotic layer; *P*, pericranium; *S*, skull. (1) Superficial hematoma or contusion in skin proper of scalp. (2) Hemorrhage or pus formation in subaponeurotic layer. (3) Subpericranial hemorrhage. The latter is the location of the hemorrhage in the cephalhematoma of infants.

loose arrangement of the connective-tissue fibers in this layer, collections of blood and pus, or edema due to any cause, are most apt to occur in this layer (Fig. 6). On account of the attachments of the occipitofrontalis to the zygoma, superior curved line, and supraorbital ridges, the spread of such fluids is limited in this subaponeurotic layer. Hence, the best place to drain this layer is along the above-mentioned line of attachment of the aponeurosis.

Beneath this layer is the external periosteal covering of the skull, the pericranium. It is firmly attached in the adult to the entire skull, but in infants is only firmly adherent along the line of the sutures. Hence, extravasations of blood or pus in this layer rarely occur in the adult, but quite frequently in infants. One of the most marked examples of this is the so-called blood-tumor frequently observed after birth as a result of the use of forceps, etc., and called cephalhematoma. It can be readily recognized if the anatomic fact is borne in mind that the limits of the swelling correspond to the line of the sutures. One of the most frequent places for it to occur is over the parietal bone (Fig. 2).

The pericranium is in reality the external periosteum of the skull, but has little to do with its nourishment, the latter being chiefly derived from the many meningeal vessels—to be described below—lying between the dura and the inner table of the skull; so that the destruction of the pericranium does not cause necrosis of the skull, as would happen if the periosteum of a long bone were stripped off.

The scalp is frequently the seat of skin diseases, especially of eczema and of favus. At times cutaneous lesions, especially of syphilis, are most characteristic at the junction of the hairy and non-hairy portions of the scalp, forming the so-called corona veneris.

Primary tumors of the scalp are rare; angiomata (nævi) occur in infants, especially in the frontal region. They may involve only the capillary vessels or the subcutaneous veins.

Dilatations of the arteries of the scalp are apt to involve many vessels, especially affecting the temporal region, forming so-called cirsoid aneurisms.

## The Cranium.

The cranium proper, or brain-case, is divided into a vertex, or vault, and a base. Together they inclose the brain and its membranes. The vertex is composed of two layers of compact bone, the outer and inner tables, between which there is a cancellated, loose-meshed bone—the diploë. In the latter there is a rich network of veins communicating with those of the scalp on one side and those in the interior of the cranium

(sinuses) on the other (see Fig. 3). It may readily be seen how infection can travel along these veins of the diploë from the exterior to the interior. In the adult the cranial bones are firmly united, and there are only traces of the sutures. The bones in the adult possess only a moderate degree of elasticity, as compared with those of children. Hence, a fall or blow upon the head in the latter will not be so apt to produce a fracture. The vertex is almost uniformly thick, the thinnest places being in the temporal regions. The base is alternately thin and thick, and it is more likely to be broken across these thinner places. The base of the skull is also weaker on account of the many foramina for the passage of vessels, nerves, and the spinal cord (see Fig. 8).

In the infant the bones of the vertex are separated by spaces which are bridged over by the pericranium and dura mater—the latter being more universally and firmly adherent than in adults. These spaces are called sutures (see Fig. 2), the most important being the sagittal, in the median line. At its anterior end is the anterior fontanelle, and at its posterior the posterior fontanelle. The anterior fontanelle is at the junction of the sagittal and coronal, the posterior at that of the sagittal and lambdoidal sutures. These openings, or fontanelles, aid in determining the position of the child's head during birth. They are closed, under normal conditions, at the end of the second year, but when a child suffers from rachitis (rickets) they remain open much longer. When a condition to be described later, known as hydrocephalus develops, the fontanelles are increased in size, bulge, and do not close at the regular time, and the sutures are widened. The sutures in the infant's skull permit the cranial bones to slide upon each other and allow the head to be moulded for its passage through the pelvis during parturition. They also permit the cranial bones to be separated to accommodate themselves to the rapidly growing brain. When they become ossified too early in life, it interferes with the growth of the brain, resulting in a condition known as microcephalus.

There is no mark externally to indicate the limits of any of the bones of the vertex, but for clinical purposes it may be said that the parietal and temporal bones on each side form the greater portion of the lateral wall and roof; the frontal, the anterior, and occipital the posterior walls.

There is similarly no external sign to indicate the situation of any of the fossæ of the base. In general, however, it may be said that the anterior fossa extends as far back as the anterior end of the zygoma, externally; that the middle fossa lies between this and the mastoid processes; and the posterior includes all of the base behind these processes.

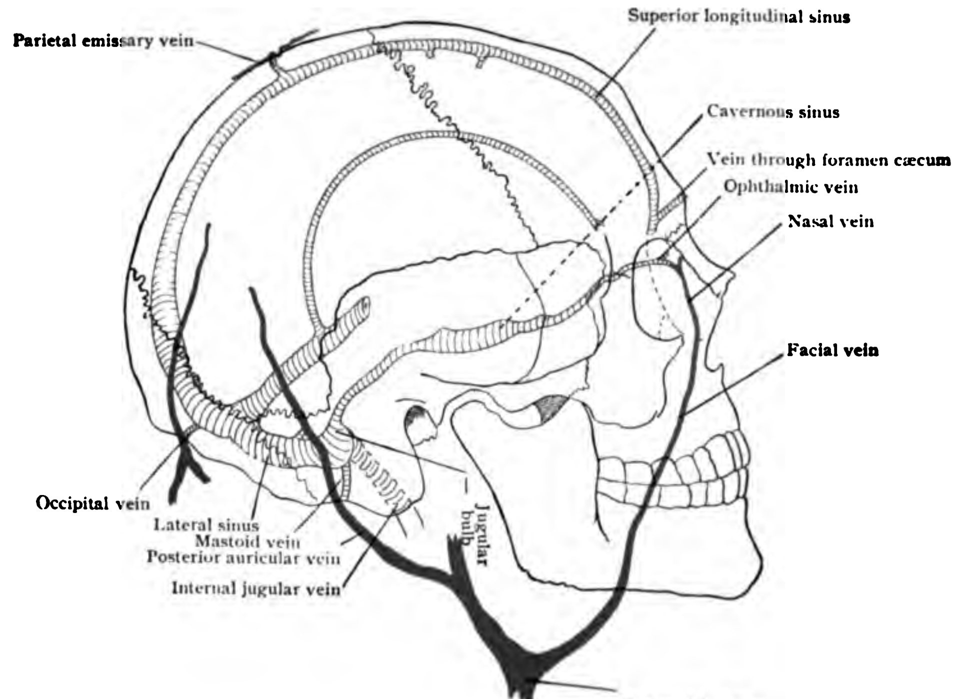


Fig. 7.—Lateral view of face and skull, showing relation of surface veins to endocranial sinuses, through the medium of the principal emissary veins (modified after Herman).

The cranium, both vertex and base, is frequently the seat of fractures, which may be produced by either direct or indirect violence. They vary from a simple crack, or fissure, to an extensive crushing in, or depression. The fracture usually involves both tables, and of these more of the inner than the outer, on account of its lesser degree of elasticity. Fractures of the vertex are most frequently the result of direct violence, and most of those of the base (over two-thirds) are due to the same causes, namely, a direct blow upon the vertex, causing a fracture extending into the base, so that the latter is broken at its weakest places. Fractures both of the vertex and base may be caused by indirect violence, such as a fall upon the feet or a blow or fall on the chin, but this is rare. It was formerly thought that a fracture could be produced at a point opposite to the place struck, by contrecoup. In the light of modern knowledge we now believe that the best way to understand fractures of the skull is to assume that the latter is an elastic sphere. Fractures can thus be produced by either compression or bursting. In the first variety (compression fractures) the bone will be compressed by the violence until its elasticity is exceeded and it gives way or breaks. The inner table being less elastic, breaks first and more extensively, and may at times be broken alone. In the second variety the elastic sphere, or skull, changes its form under the influence of the force like a rubber ball would, and will finally yield at some meridian where its elasticity has been exceeded. The former (compression) fractures occur most frequently on the vertex, extending often into the base. Were the skull a perfect spheroid, with uniform thickness and power of resistance, one could calculate where a fracture would be, knowing the point of impact. But as stronger and weaker portions alternate, especially in the base, one can only say that the elasticity is more likely to yield at such thinner places, and we find clinically that fractures through the orbital plate and through the occipital bone are most frequent (Fig. 8), involving also the apparently more solid petrous portion of the temporal bone, on account of the bone being weakened by the carotid and jugular canals.

The symptoms which a fracture or any disease of the bones of the skull may cause through injury of the brain and its membranes, or any of the nerves or vessels which lie in close relation to the bones, will be taken up in the section upon cranial contents.

Acute or chronic inflammations of the cranial bones, are not as frequent as in the long bones of the body. Acute osteomyelitis is very rare, but acute inflammation of the pericranium (periostitis) occurs during the secondary stage of syphilis, accompanied by violent nocturnal pains. Chronic inflammation as the result of the ordinary pyogenic organisms

may occur as a result of an infected fracture of the vertex, but th necrosis following it is usually not very extensive.

Tuberculosis and syphilis are perhaps the most frequent causes o inflammation of the cranial bones. The former is especially frequen in the temporal bone, particularly in children. Syphilis causes extensiv necrosis during its tertiary stages, which may involve the entire thicknes of the skull. Both of these diseases may give rise to localized or, mor rarely, to diffuse inflammation of the periosteum proper (dura mater of the skull, causing pressure-symptoms in the brain and upon th cranial nerves at the exits of the latter (syphilitic periostitis and men ingitis).

Congenital malformation of the skull is most frequently a gap i either the frontal or the occipital bone, rarely in the parietal bon Such a fissure may be mistaken for a fracture. In the frontal bone it usually situated close to the glabella. Through such an opening the may be a hernia or protrusion of either the membranes of the brain even of some portion of the brain itself. If the protrusion contains on membranes, it is called a meningocele; if both brain and membranes, meningoencephalocele; and if in addition a ventricle (lateral), hydre cephalocele. In infants they may be recognized by their situation ar the fact that they become tense and more prominent when the child crie They may also occur after fractures of the skull.

Acquired malformations of the skull may be caused by rachit The head assumes the shape of a box, its lateral and anteroposteri diameters becoming almost equal. Another condition, known craniotabes, is also the result of the same disease. It is due to a gradu absorption of bone, especially in the occipital bone, so that the sk becomes almost translucent at these places and feels very soft to t touch.

Tumors of the skull bones are infrequent, especially primary. the latter osteoma and sarcoma are by far the most common. Seconda tumors, either by metastasis or by extension from the brain or mening are more frequent.

## Cranial Contents.

The cranium incloses the brain, its membranes, and their bloc vessels. It has numerous foramina, especially at the base, for the passa of vessels leading to and from the brain and its membranes, as well for the exit of the cranial nerves and the spinal cord. It also conta the blood-supply of some of the end-organs of special sense, like the and ear, which are in close relation to the cranial cavity.

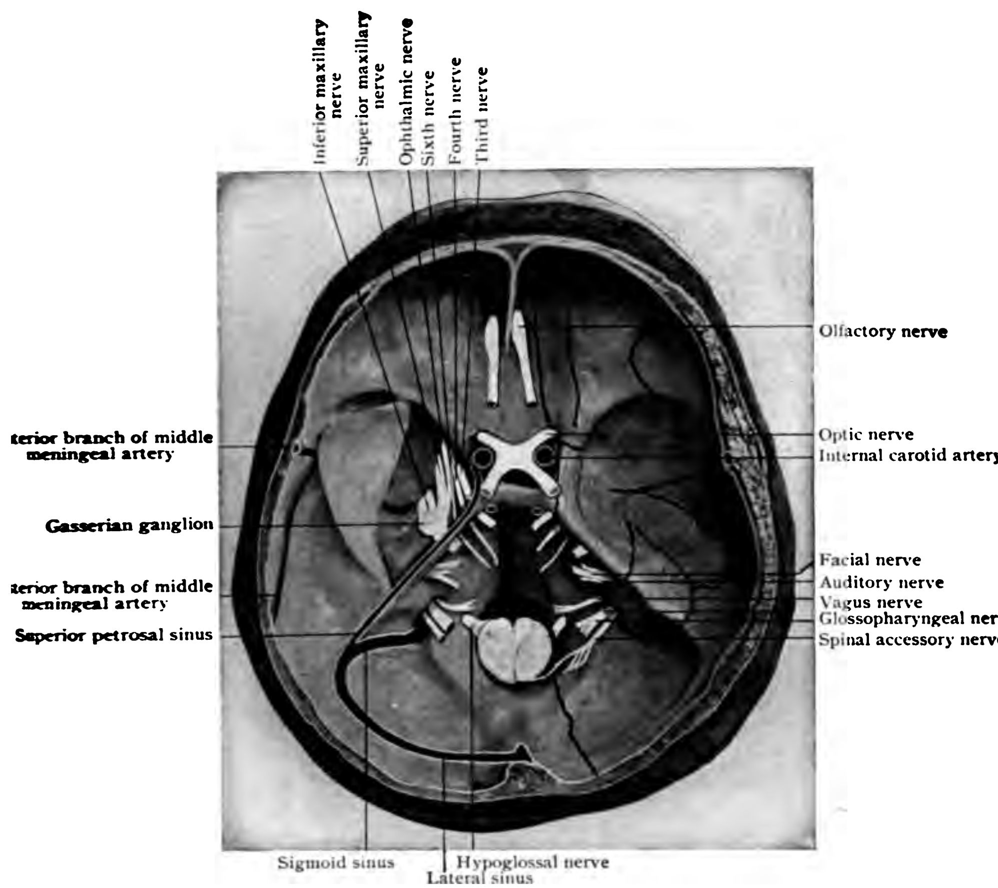


**Fig. 8.**—View of base of skull, showing relation of cranial nerves, carotid and middle meningeal arteries, and sinuses to the fossæ. This illustration shows on the right side of the skull the most frequent lines of fracture at the base of the skull.

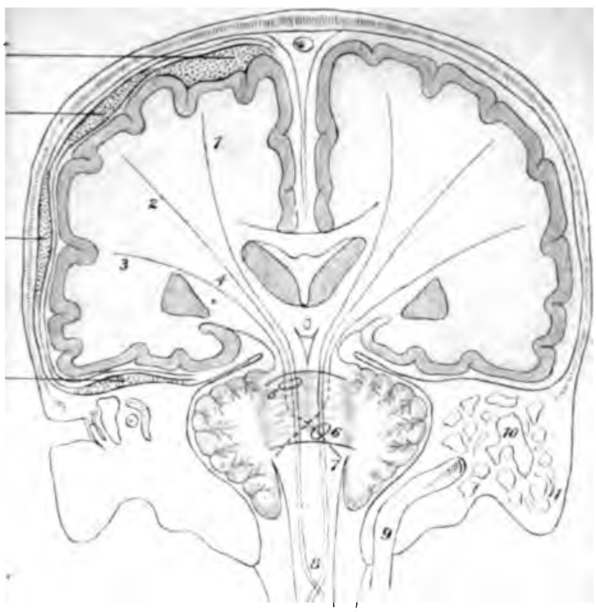


Fig. 9.—Coronal section of skull through middle of petrous portion of temporal bone (semi-diagrammatic), to illustrate the position of meningeal suppurations, especially with reference to middle-ear and mastoid disease. The illustration also serves to show the course of the principal motor tracts through the internal capsule and pons. 1, Motor fibers for leg. 2, Motor fibers for arm. These can be followed down through the pons Varolii until they cross in the pyramids (8). 3, Facial fibers, which cross the pons, and emerge from it to form the facial nerve (7). 4, Internal capsule. 5, Focus in upper portion of pons, causing paralysis of the face and extremities of the same side. 6, Focus in lower portion of pons, causing paralysis of the facial on same side of body as lesion, and paralysis of the extremities on opposite side of body. 9, Jugular vein and lateral (sigmoid) sinus, showing the close relation of the mastoid cells and antrum (10 and 11 respectively) to the temporosphenoidal lobe, cerebellum, sigmoid sinus, and its continuation in the jugular vein. An inspection of the middle ear on the left side of the picture, and of the mastoid cells and antrum upon the right side, will give an idea of the anatomic relations of middle-ear suppuration to endocranial structures.

The **membranes** are the dura, pia, and arachnoid. The **dura** (see Figs. 3 and 9) forms the internal periosteum of the skull. In children it is more closely attached both at the vertex and base than in adults, especially so at the sutures. It sends out sheaths or prolongations for each of the cranial nerves, so that infection may readily travel along these from the exterior of the skull, and any obstruction to the flow of cerebrospinal fluid within these sheaths will cause symptoms of stagnation to appear; for example, the choked disc in the optic nerve as a result of tumors or abscesses of the brain. The dura is composed of two layers. The outer is closely applied to the cranial bones and is separated from them only by numerous meningeal vessels which lie in grooves in the bone and supply the bone and dura (see Figs. 3 and 8). The inner layer of the dura is smooth, and like the pleura in structure, being covered with smooth endothelium. The two layers of the dura separate at certain points to form sinuses for the return of blood from the brain and the cranial bones (see Figs. 3, 8, 11, and 12). Many of these lie in such close relation to the bone that they may be torn by a fracture; *e. g.*, longitudinal, lateral, and cavernous. Of these, the lateral is least frequently injured. The two layers of the dura also inclose the Gasserian ganglion, which it is important to remember in operations for the removal of this structure (see Figs. 8 and 10). The inner layer of the dura forms a membrane, the **falx cerebri,** separating the two hemispheres in the median line; and also forms the **tentorium cerebelli,** separating the posterior half of the cerebrum from the cerebellum (see Fig. 12). The **middle meningeal artery** enters the middle fossa through the foramen spinosum. It then passes across to the vertex, its trunk corresponding (see Figs. 8, 11, and 12) externally to about the middle of the zygoma. Just above this point it divides into an anterior branch which passes almost vertically upward, and a posterior which passes obliquely backward. Its close relation to the skull bones renders it peculiarly liable to injury through a fracture of either base or vertex, and the accumulation of a large clot of blood between the dura and the skull (epidural clot, in Fig. 9). The dura itself may be torn, allowing the blood to become more diffused (subdural hemorrhage). In either case compression of the underlying brain results. On account of the firmer attachment of the dura to the skull in children, epidural hemorrhage is rare at this age.

When any portion of the skull-cap is removed during life, one can see a distinct pulsation of the dura, synchronous with the respiratory movements. This is not due to the pulsation of the brain itself as the result of arterial pulsation, but to the rise and fall of blood pressure caused by expiration and inspiration respectively. This pulsation is absent or

decreased when there is any increase of intracranial pressure, such as occurs in meningeal hemorrhages, tumors, etc.

The other two membranes of the brain must be considered as one, called the **pia-arachnoid,** it being impossible to separate the fine network forming the pia from the arachnoid, whose outer surface is smooth, and has been compared to the visceral layer of the pleura, the parietal layer being formed by the smooth inner surface of the dura. The space between the dura and the pia-arachnoid is called the **subdural space** (see Figs. 3 and 9). Collections of blood and pus may occur here and become widely diffused, at times extending to the base and causing death through pressure upon the pons and medulla. This subdural space is continuous with that of the spinal cord, so that infection may rapidly extend along it to the cord, and *vice versa* (meningitis). The subdural space contains fluid whose origin is not clear. In cases of fracture of the skull when the dura is torn this fluid may escape through the wound.

The pia-arachnoid bridges over the depressions or sulci between the convolutions. It contains an elaborate system of veins and arteries, between which a fluid floats in its fine meshwork known as the **cerebro-spinal fluid.** The system of spaces is an exceedingly intricate one, and permits of free communication between the lymph bathing the convexity of the brain and that of the large spaces at its base, thus forming a sort of water-bed for the brain, and greatly diminishing the effects of blows upon the head. This **subarachnoid space** communicates with the same space surrounding the spinal cord, and also with the ventricles, through the foramen of Magendie in the roof of the fourth ventricle. Hemorrhages are more apt to occur into the subarachnoid space in children than in adults, and are a frequent cause of death after forceps operations. The foramen of Magendie may become closed during infancy, so that the fluid within the ventricles (where the cerebrospinal liquid is secreted) accumulates, causing a condition known as hydrocephalus. In this the lateral ventricles become enormously distended, causing pressure-atrophy of the surrounding brain and producing an increase in the size of the head through separation of the bones so that the face seems like a mere parasite upon the enormous skull. Various unsuccessful efforts have been made to relieve this condition by tapping the ventricles.

All varieties of infective inflammation of the meninges may occur, either of an acute or a chronic type, and the products of the same accumulate in the epidural, subdural, or subarachnoid spaces (see Fig. 9), being more easily diffused in the second, as stated above. There is no communication between the subdural and subarachnoid spaces, so that


Fig. 10.—Photograph of a wax model of the skull, showing the relations of the cranial nerves. 1, Gasserian ganglion, with its three branches, the ophthalmic (2), the superior maxillary (3), and inferior maxillary, the principal branches of which are the lingual (4), and inferior dental (5). Along the course of the superior maxillary the otic ganglion (10), is to be seen. 6, Facial nerve on outer side of ramus of lower jaw. It can be followed backward to its point of emergence, stylomastoid foramen, where its distance from the surface of the mastoid process is to be noted. 7, Vagus nerve. 8, Cervical sympathetic, the figure 8 being placed upon the superior ganglion. 9, Placed upon the optic nerve. Below the figure is to be seen the sixth or abducens nerve; above it the third and fourth nerves. By following these nerves backward their relations to the Gasserian ganglion and internal carotid artery and cavernous sinus can be studied.

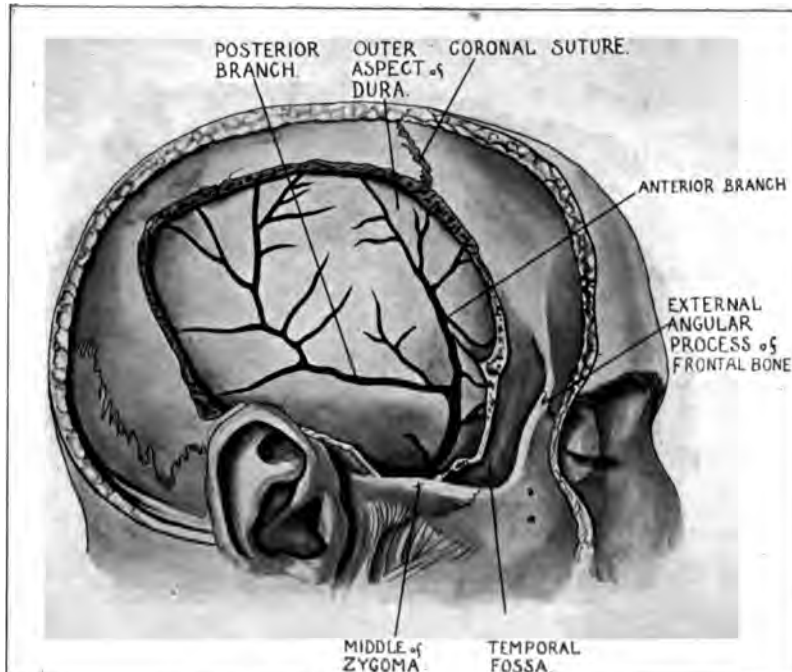


Fig. 11.—Topography of middle meningeal artery (after Zuckerkandl).

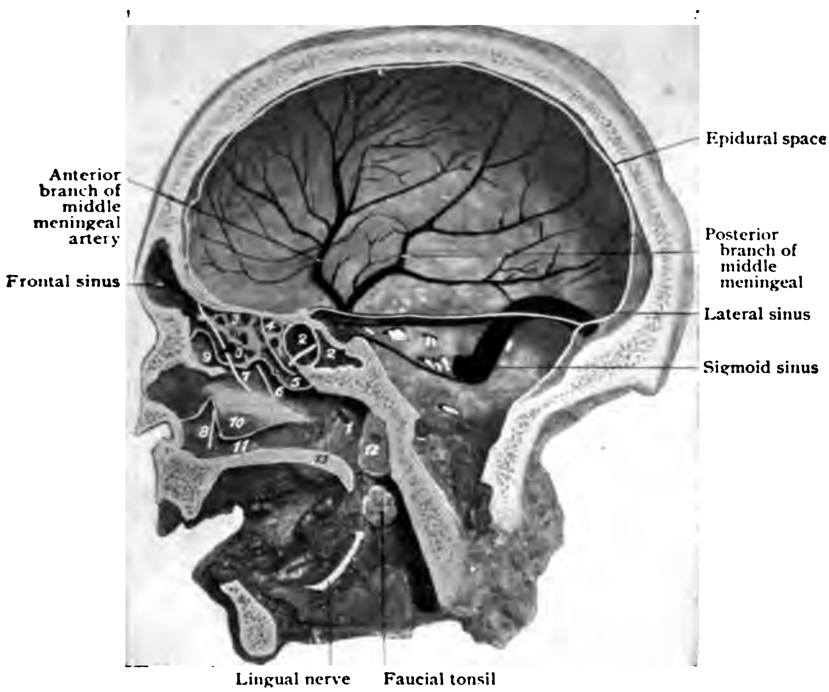


Fig. 12.—Sagittal section of skull to show the distribution of the middle meningeal artery as viewed from the interior of the skull, the lateral sinus, and the relations of the accessory sinuses, lachrymal duct and orifice of Eustachian tube to the nose. This illustration also shows the position of the pharyngeal or tonsil of Luschka and of the faucial tonsil. 1, Orifice of Eustachian tube on lateral wall of nasopharynx. 2, Sphenoidal cells, opening into superior meatus (5), at point indicated by white line. 3, Anterior ethmoidal cells, opening into middle meatus. The middle turbinated bone has been removed, leaving only its point of attachment. 4, Posterior ethmoidal cells, opening along white line into superior meatus (5). 6, Placed in middle meatus along white line, the upper end of which indicates the opening of the antrum of Highmore into the middle meatus. 7, Placed over a white line which indicates the opening of the frontal sinus at the hiatus semilunaris in the middle meatus, close to the opening of the antrum. 8, Placed in front of a straw indicated by a white line, showing the opening of the lachrymal duct into the anterior portion of the inferior meatus, a portion of the inferior turbinated bone (10) having been removed. 9, Anterior end of middle turbinated. 11, Inferior meatus. 12, Pharyngeal or tonsil of Luschka (adenoid vegetations). 13, Placed at junction of soft and hard palate.

infection of one does not readily spread to the other. An inflammation of the dura mater is called a pachymeningitis interna, or externa, according to whether it is situated on the inner or outer side. An inflammation of the pia-arachnoid is called leptomeningitis.

Epidemic cerebrospinal and suppurative meningitis are usually most marked in the pia-arachnoid, and quite diffuse over the convexity and base. The more chronic types of inflammation, like tubercular and syphilitic, are more marked at the base, and are apt to cause focal symptoms through pressure on nerve-trunks (Figs. 8 and 9).

The **leptomeninx,** as the pia-arachnoid is called, receives its arterial supply through the meningeal branches of the circle of Willis at the base; its veins empty into the sinuses of the dura (Fig. 3). The arteries send in branches to the cortex (see Fig. 3), thus establishing a cortical circulation quite distinct from that of the interior of the brain and basal ganglia, to be referred to later, which are supplied directly from the vessels at the base. Hence, an obstruction in the latter will not always interfere with the circulation in the cortex. The meninges are supplied by the fifth cranial and the sympathetic nerves, so that inflammation of or pressure on them causes the pain to be referred to the corresponding portion of the scalp, also supplied principally by the fifth nerve. This is of importance in the localization of intracranial lesions, and its severity is an index of the degree of intracranial pressure.

The brain will be discussed only in its topographic and clinical relations. A previous study of its anatomy is presupposed. It consists of **two cerebral hemispheres** which are held together by a broad commissure, the **corpus callosum** (see Fig. 9). They contain a cortical, or gray, and a central, or white, portion. The former is made up of nerve-cells and their continuation into the central portion. This latter part is made up of a number of nerve-fibers (internal capsule) serving to connect the cortex with the peripheral portions of the body, and also of a number of nuclei of gray matter, the **caudate and lenticular nuclei and optic thalamus** (see Fig. 9). These fibers are gathered together at the base of the brain in the peduncles of the brain, and are continued in the structures at the base known as the pons and medulla. The latter, in addition to serving as support for conducting tracts of fibers from the cortex and the gray nuclei, have a number of collections of highly organized nerve-cells in which many of the cranial nerves arise.

The **medulla oblongata** contains the nuclei of origin of many of the cranial nerves and is the seat of many of the automatic centers, like those of circulation, respiration, sweating, heat regulation, etc.

Separated from the cerebral hemispheres by a fold of dura (tentorium) is the **cerebellum** (see Figs. 9 and 12), also showing two hemispheres made up, like the cerebral, of a cortical gray nerve-cell and a central white conducting tract. The latter fibers pass to the medulla and pons, and have, as a portion of their function, the maintenance of equilibration and co-ordination through their connection with the sensory tracts arising from the cord, and with the centers of hearing in the cortex.

The circulation of the cerebrum is derived from two sources—one, the cortical (see Fig. 3); and the other, the basal. The latter vessels are chiefly derived from the middle cerebral artery, which is, in reality, a direct continuation of the internal carotid. The branches of this vessel ascend directly toward the central portions of the hemispheres which they supply, and are end-arteries, so that emboli swept away from the heart into the carotids and lodged at the beginning of the middle cerebral will cut off the blood-supply of these basal ganglia and of the internal capsule, causing paralysis of the opposite side of the body (see Fig. 9).

Similarly, a thrombosis of these vessels will cause an anemic necrosis. These vessels are frequently the seat of an arterial degeneration, or of minute aneurism formation, the result of various general causes (senility, syphilis, Bright's disease, etc.), and will burst, causing the blood to escape into and destroy the fibers of the internal capsule (see Fig. 13, internal capsule).

Physiologic and clinical investigations have enabled us definitely to locate certain centers in the cortex of the cerebrum (see Figs. 2, 14, and 15). These are:

1. Center of speech ........Third left frontal convolution in right-handed people, and on right side in left-handed people.
2. Centers of motion .......For leg, in upper third of ascending frontal and ascending parietal convolutions around fissure of Rolando.
   For arm, in middle third of same.
   For face, in lower third of same.
3. Center for hearing (sensory aphasia) .........First temporosphenoidal convolution.
4. Center for sight .........Occipital lobe (cuneus).
5. Center for general sensation .................Probably in parietal lobe.


Fig. 13.—Horizontal view of internal capsule (Ziehen).

A glance at figures 9 and 13 will give some idea of the effect of lesions situated at various portions of the conducting tracts which pass from the cortical centers to the extremities. A lesion in the left internal capsule will cause motor aphasia and paralysis of the face, arm, and leg on the right side of the body. It may also cause disturbance in sensation on the opposite side of the body. A lesion in the right internal capsule will cause the same symptoms, except loss of speech, on the left side of the body. A lesion of the occipital lobe will cause blindness in the corresponding halves of the field of vision. If on the left side, of left halves (left lateral hemianopsia). A lesion affecting the motor centers around the fissure of Rolando will cause at first spasm of (through irritation), and later paralysis of the face and extremities of the opposite side of the body. Lesions of the temporosphenoidal lobe will cause word deafness. Lesions of the pons will give rise, according to its location, to paralysis of the facial muscles on one side, and of those of the extremities on the opposite side, due to the fact that the latter cross at a lower level (see Fig. 9). Lesions of the pons and medulla give rise to symptoms involving the functions of the fifth to twelfth nerves (see below) and of the higher automatic centers. Lesions of the cerebellum cause ataxia and vertigo.

The following portions of the brain, its vessels and cranial nerves, lie in close contact with, or pass out through the fossæ of the base of the skull (see Figs. 8 and 12).

| | |
|---|---|
| Anterior fossa ............ | 1. Frontal lobes. |
| | 2. Olfactory nerve. |
| Middle fossa ............. | 1. Temporosphenoidal lobes. |
| | 2. Cavernous sinus. |
| | 3. Internal carotid artery. |
| | 4. Optic nerve (II). |
| | 5. Motor oculi nerve (III). |
| | 6. Trochlear (IV). |
| | 7. Trigeminal nerve (V). |
| | 8. Abducens (VI). |
| Posterior fossa............ | 1. Cerebellum. |
| | 2. Occipital lobes. |
| | 3. Lateral sinus. |
| | 4. Seventh, eighth, ninth, tenth, eleventh, and twelfth nerves. |

The symptoms of fractures of the base vary with the fossa injured, and may be said in general to be:

*Anterior fossa*............1. Escape of blood or cerebrospinal fluid through nose and mouth (fracture of cribriform plate of ethmoid).
2. Anosmia.
3. Extravasation under conjunctivæ.

*Middle and posterior fossæ*..1. Escape of blood or cerebrospinal fluid from ear.
2. Paralysis of second, third, fourth fifth, and sixth nerves.
3. Formation of pulsating exophthalmos or of aneurism externally due to injury of either cavernous sinus or internal carotid, or of both, with formation of arteriovenous aneurism.
4. Facial paralysis due to injury of seventh nerve, side of injury or lesion.
5. Deafness due to injury of eighth nerve.
6. Bulbar symptoms due to involvement of ninth to twelfth nerves.
7. Symptoms of hemorrhage due to injury of either middle meningeal artery or lateral sinus (rare).

The same symptoms of involvement of the cranial nerves may be caused by tumors, periostitis, etc., pressing on them at the base of the skull.

Symptoms of injury or of pressure on various cranial nerves are:

I. Olfactory nerve .....Loss of sense of smell.

II. Optic nerve ........Blindness in corresponding halves of retina (if behind commissure) of each eye (hemianopsia).
Blindness in corresponding eye (if in front of commissure).

III. Motor oculi nerve ...Ptosis—External strabismus—Dilated pupil.

IV. Trochlearis.........Inability to turn eye down and outward, so that double vision is complained of.

V. Trigeminal.........Loss of sensation over cornea and face.
Loss of power of mastication.

| | |
|---|---|
| VI. Abducens .......... | Internal strabismus. |
| VII. Facial ............. | Paralysis of facial muscles and of buccinator. |
| VIII. Auditory ........... | Deafness. |
| IX. to XII. Glossopharyngeal, Vagus, .........., Spinal accessory, ., Hypoglossal, ..... | Bulbar symptoms: indistinct articulation, atrophy of tongue, difficulty in swallowing, paralysis of sternocleidomastoid and trapezius muscles (XI). |

Symptoms of injury may appear as a result of a tear of the nerve at the base, without fracture.

## Craniocerebral Topography.

Relations of surface of skull to principal blood-vessels, fissures, and centers of brain (see Figs. 2 and 14).

**The fissure of Rolando,** around which lie the motor centers, may be found by several methods, either by a special instrument, a Rolandometer, or by finding a point which is one centimeter (½ inch) behind the center of a line extending from the glabella in front to the inion behind, and measuring from it an angle of 67 degrees downward and forward.

**The fissure of Sylvius,** below which lies the temporosphenoidal lobe. Its beginning corresponds to a point four centimeters (1¾ inches) above the middle of the zygoma, and from this it extends slightly upward and backward.

**The Middle Meningeal Artery.**—Its main trunk corresponds to the middle of the zygoma (Kocher). A little above this (see Figs. 11 and 14) it divides into an anterior and a posterior branch. The former, which is the larger, may be found by trephining at a point one and one-quarter inches behind the external angular process of the frontal bone, and one and one-half inches above *Reid's base line* (a line drawn through the lower border of the orbit and external auditory meatus to the occiput). Of late years the Krause-Hartley flap has been suggested to expose the artery.

**The superior longitudinal sinus** corresponds to a line drawn from the glabella in front over the median line of the vertex to the inion behind (see Figs. 2 and 14).

**The lateral sinus** (see Figs. 2 and 14) corresponds to a line drawn from the external occipital protuberance to the base of the mastoid process, and from the latter line to its tip at a deeper level.

## The Ear.

The ear is divided into three parts, the external, middle, and internal ear. Of these the middle ear, or tympanic cavity, is of the greatest interest clinically. The external and middle portions of the ear serve as a most ingeniously constructed receiving and conducting apparatus for sound-waves, which are transmitted to the receiving portion or internal ear.

The **external ear** includes the portion seen externally, and commonly known as the ear, and a canal (the external auditory) about an inch and a quarter long, partly bony (temporal bone), and partly cartilaginous; the latter is a continuation of the cartilage of the external ear, and both bony and cartilaginous portions of the external auditory canal are lined by skin, which is an extension inward of that of the scalp and ear. This skin is of very fine structure and firmly attached to the underlying cartilage and periosteum, so that a small furuncle will cause but little swelling, and yet give rise to a disproportionately great degree of pain, owing to the high tension under which the pus collects. The external ear is richly supplied with blood-vessels, principally from the temporal and posterior auricular arteries and veins, so that wounds heal readily. Owing to the above-mentioned close connection between the skin and underlying cartilage, only moderate subcutaneous hemorrhage and swelling occur. The exposed position of the ears causes them to be the seat of congelation or freezing frequently. Their vascularity is so great that, as in the scalp and face, the entire ear may be torn of except a narrow pedicle which contains an artery and yet may hea again.

The external auditory canal is in close relation to the parotid glan and temporomaxillary joint in front, and to the mastoid cells behind By placing the finger in the ear one can feel the movements of the joint The relation of the canal and mastoid cells causes abscesses of thes structures, especially of the parotid, to perforate the canal; pus escapin through the external ear. The skin of the canal in its outer portio contains many fine hairs, sebaceous and ceruminous glands. These ar only present close to the external meatus, so that furuncles and earwa are usually found in the outer portion of the canal. The skin of tha portion of the auditory canal close to the membrana tympani is smoot and glistening, and contains no hairs or glands. The canal is directe downward and forward, and is somewhat bent upon itself, so that it i necessary to pull the external ear upward and backward in order to obtai a clear view of the tympanic membrane. The posterior wall of the can receives sensory fibers from the vagus, so that foreign bodies inserte

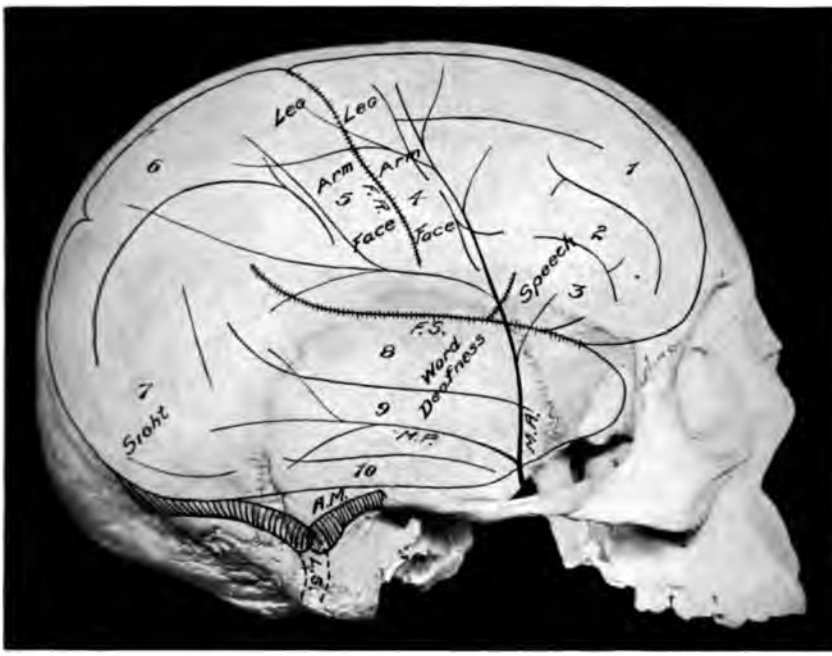


Fig. 14.—Relation of fissures of Rolando and Sylvius, of the lateral sinus, convolutions of brain, and of middle meningeal artery to skull. M.A., Anterior or ascending branch of the middle meningeal artery. M.P., Posterior or horizontal branch of the middle meningeal artery. These two join so that the main trunk lies about opposite the middle of the zygoma. F.R., Fissure of Rolando, lying between 4, the ascending frontal, and 5, the ascending parietal convolution. F.S., Fissure of Sylvius, that is, the horizontal limb. 1, 2, and 3, First, second, and third frontal convolution. 6, Parietal lobe. 7, Occipital lobe. 8, 9, and 10, First, second, and third temporal convolution. L.S., Lateral sinus. The dotted line shows that portion of the lateral sinus which descends on the inner side of the mastoid process (sigmoid sinus). The remainder of the lateral sinus is shown passing somewhat horizontally backward beneath the occipital lobe (7). A.M., Projection of mastoid antrum, on surface.

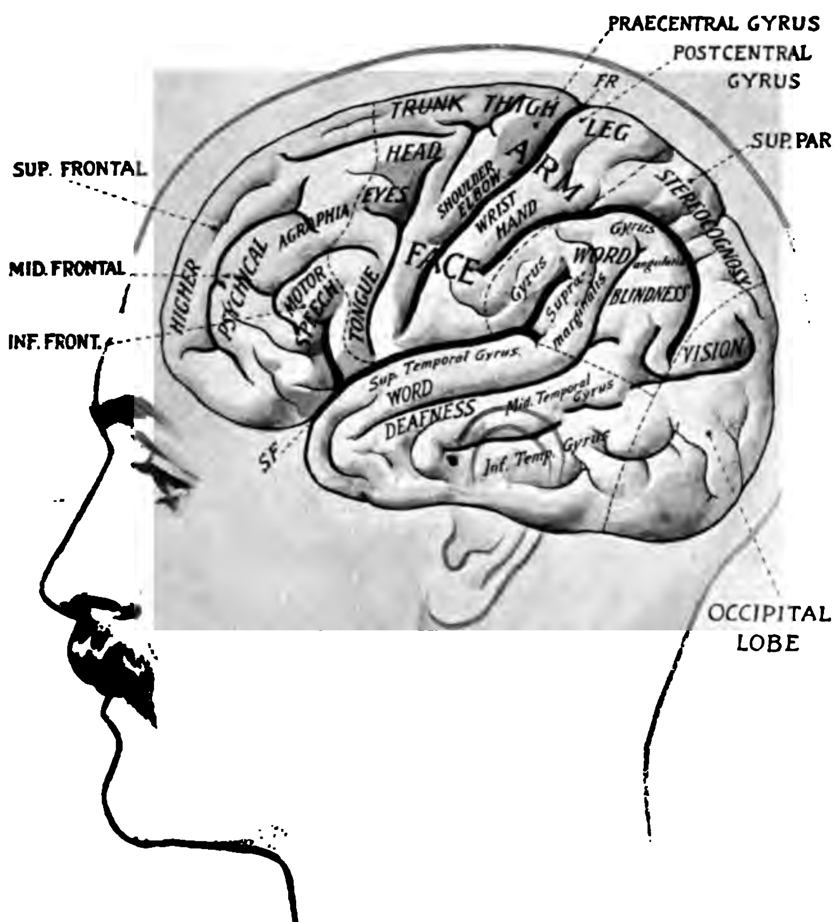


Fig. 15.—Cerebral localization. SF, Fissure of Sylvius. RF, Fissure of Rolando.


Fig. 16.—Coronal section of skull made through middle of petrous portion of temporal bone as seen looking backward into posterior fossa. 1, Internal jugular vein at its beginning, the white line indicating a straw which was passed from the termination of the sigmoid sinus through the jugular bulb into the jugular vein. 2, External auditory meatus, at the inner end of which one sees the membrana tympani forming an angle of 45 degrees with the horizon. Attached to the middle of the membrana tympani can be seen the malleus and incus (to malleus). Above these bones is seen the epitympanic space (4). The section has been made rather obliquely, so that on the right side of the skull it passes through the petrous portion of the temporal bone a little further back, showing the mastoid antrum (3), surrounded by the mastoid cells. 5, Beginning of spinal canal at posterior fossa of skull. 6, Torcular Herophilii, showing the point of meeting of the longitudinal sinuses and the lateral sinuses (8). 7, Section of inferior petrosal sinus.

into the ear by children, or ear-wax, etc., may cause reflex attacks of coughing and vomiting.

The **middle ear** begins externally at the membrana tympani, a fine membrane, which is firmly attached to a ring of bone (annulus tympanicus). The latter is complete except at its upper portion, and the membrane covering this little gap is called Schrapnell's, being less tense than the rest. The tympanic membrane and its ring form an angle of forty-five degrees with the horizon (see Figs. 9 and 16), and it is placed obliquely to the median line of the head. Looked at through an ear speculum, which must not be inserted into the auditory canal until the ear has been pulled upward and backward, one sees the handle of the malleus attached to the center of the membrane. One can follow the handle upward and forward to the periphery, where the more flaccid portion of the membrane (Schrapnell's) is, corresponding to the gap in the tympanic ring above referred to.

Across the upper portion of the membrane passes the chorda tympani nerve (branch of facial). Hence, one should always perform paracentesis in the lower half. Under normal conditions the membrane is slightly retracted, the center of the depression corresponding to the center of the membrane (umbo). From this point downward and forward one can see a triangular glistening area with its base toward the periphery (light reflex). Under pathologic conditions the membrane may either bulge (pus in middle ear) or be markedly retracted (chronic catarrh).

Perforations of the membrane are most frequent in the lower quadrants.

The **tympanic cavity,** or middle ear, contains the ossicles, or little bones, which transmit vibrations from the tympanic membrane to the small opening in its inner wall, which is the beginning of the receiving portion of the ear (fenestra ovalis of internal ear, Fig. 16). It is lined by mucous membrane, which is so firmly attached to the periosteum that inflammation of the former rapidly spreads to the latter, causing necrosis.

The middle ear is in communication with a complicated series of pneumatic cells in the mastoid process, and also with the nasopharynx through the Eustachian tube (Fig. 17).

The tympanic cavity, or middle ear, may be compared to a box with primitive anterior and posterior sides. The outer side is formed by the tympanic membrane, the inner by the bony labyrinth of the internal ear.

Its upper side or roof (tegmen tympani) is formed by a thin plate

of bone which separates it from the dura mater and temporosphenoidal lobe (see Figs. 9 and 16). This may be exceedingly thin at times, or even have openings so that infection can spread rapidly through it. The floor is formed by a similar lamella of bone separating it from the internal carotid artery. This may also be very thin, or imperfectly developed (Fig. 17).

Its anterior and posterior walls are very rudimentary. In the former, or really at the anterior part of the inner wall, is the opening of the Eustachian tube. At the upper back portion of the outer wall, *i. e.*, above the tympanic membrane, is the opening of the mastoid antrum, and a little more internally, on what is in reality the posterior side of the box, is the ridge under which the facial nerve lies as it passes through the petrous portion of the temporal bone. These relations are seen in figures 16, 17, and 19.

The position of the **mastoid antrum** can be understood from figures 14 and 17. It varies in size in different persons and communicates with a number of spaces (mastoid cells) in the mastoid process in which it is located. It opens into the upper and posterior part of the outer wall of the middle ear. Just back of the mastoid process lies the lateral sinus, and a little farther behind, the cerebellum (Figs. 8 and 17). These relations are very important in the causation and spread of infection of the middle ear, for the following reasons:

1. Micro-organisms travel along the Eustachian tube from the nasopharynx and cause suppurative middle-ear disease, especially after influenza, scarlatina, diphtheria, etc. (Fig. 17).

2. Chronic nasopharyngitis spreads to the middle ear through continuity of mucous membrane along the Eustachian tube, and is one of the most frequent causes of middle-ear catarrh and resultant deafness.

3. The position of the facial nerve, so close to the tympanic cavity and mastoid cells, explains its frequent involvement in inflammations of either or both, and also its injury in mastoid operations (Figs. 8 and 19).

4. The direct communication of the mastoid cells and antrum with the middle ear permits of the transmission of infection from one to the other.

5. The proximity of the brain (over fifty per cent. of all abscesses in the brain are in the temporosphenoidal lobe, following middle-ear infection), of the dura, and of the lateral sinus to the tympanic cavity and mastoid cells renders it easier to understand the frequency of sinus phlebitis and thrombosis, of septic meningitis, and of epidural, subdural, cerebral, and cerebellar abscesses, after suppurative processes of the middle ear (see Fig. 9).


**Fig.** 17.—**Horizontal section of skull to show Eustachian tube, etc. The posterior half of the section is made at a slightly higher level than the anterior half. The entire section is looked at from above.** S, Septum of nose. 1, Two white lines representing probes which show the point of opening of the Eustachian canal into the nasopharynx. They can be followed back upon each side into the middle-ear cavity, indicated by the figure 10. 2, Antra of Highmore. 3, Sphenoidal sinus. 4, Internal carotid canal. 5, Jugular bulb at termination of sigmoid sinus (6). 7, Foramen magnum. 8, Middle fossa of skull. The black line indicates the course of the middle meningeal artery. 9, Groove for Gasserian ganglion. 10, Cavity of middle ear. Its relations to the mastoid and lateral sinus can be well seen on the right side. 11, Posterior fossa of skull.

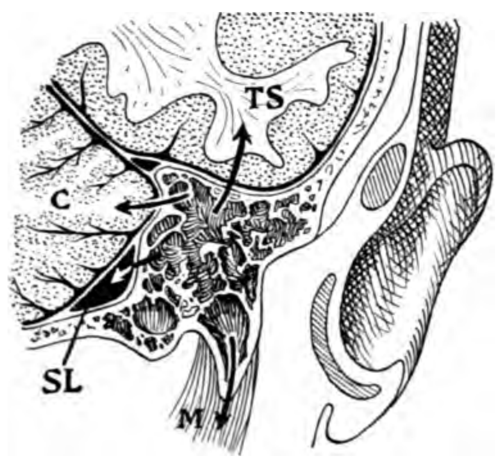


Fig. 18. -Modes of transmission of infection from mastoid process. The arrows show the direction in which infection travels: (1) into temporo-sphenoidal lobe, TS; (2) into cerebellum, C; (3) into lateral sinus, SL, and M, free apex of mastoid into tissues of the neck.

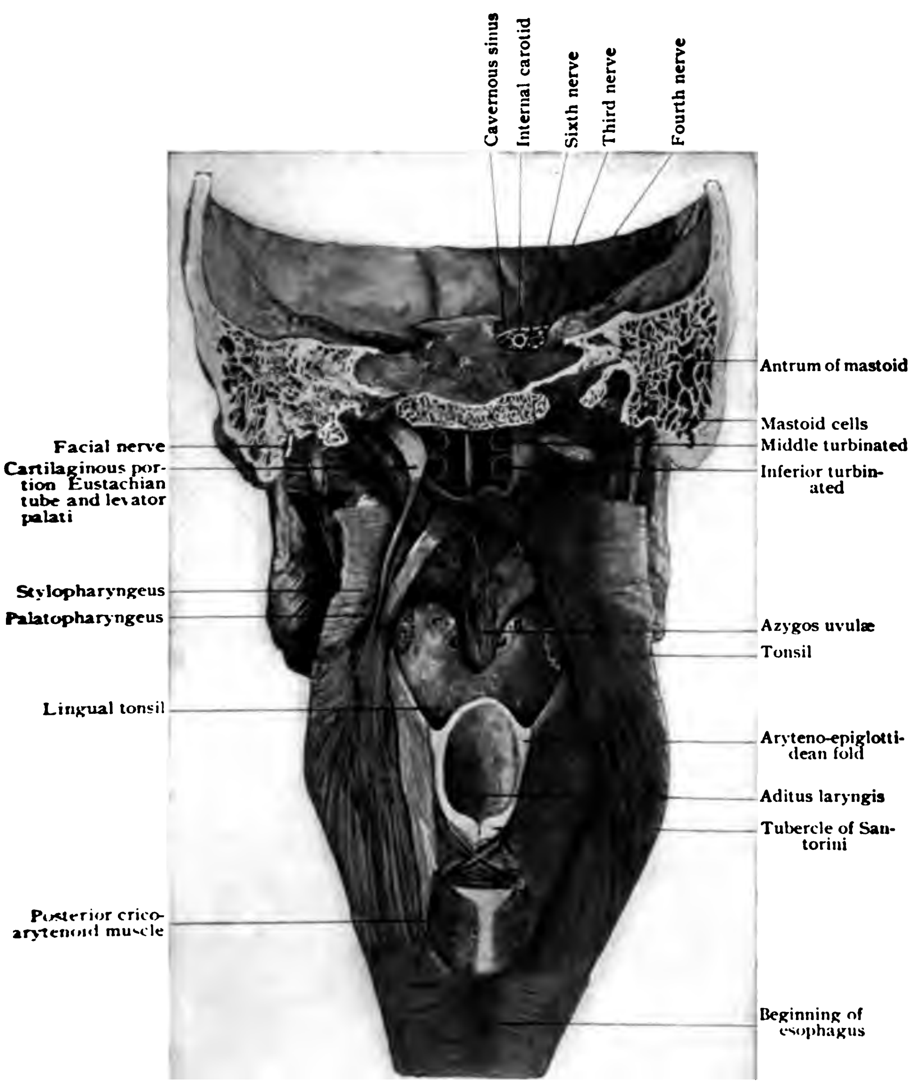


Fig. 19.—Posterior view of pharynx and larynx, as shown in a coronal section of the skull made through the level of the mastoid processes

It is exceedingly important to understand these anatomic relations when at the bedside of one suffering from middle ear complications. The mastoid antrum is also separated from the middle fossa of the skull by a thin plate of bone, the tegmen antri, so that infection may spread directly from it to the overlying brain meninges and lateral sinus. The location of the mastoid antrum is well seen in figure 14, also its relation to the lateral sinus. Externally, it corresponds to a slight depression just behind the bony elevation, known as the spine, immediately above the upper border of the bony external meatus. The mastoid process contains a large number of cells which open into the antrum. In children they are poorly developed, so that the process consists chiefly of the antrum. In adults the periosteum is firmly attached to the process, so that pus is less likely to escape through it than in children. In opening the antrum of the mastoid care should be taken not to chisel too high, for fear of entering the middle fossa; nor too far behind, owing to the position of the lateral sinus; nor too deep, on account of the proximity of the facial nerve (Figs. 16, 17, and 19). If one desires to establish, as is frequently done in chronic suppurative otitis media, a free communication between the antrum and middle ear, it is necessary to chisel away the posterior wall of the bony external auditory meatus.

Thrombosis of the lateral sinus sometimes spreads to the petrosal and cavernous sinus, but more frequently into its terminal vein,—the internal jugular (Fig. 16),—from which point septic emboli may be carried first to the lungs and later cause a general pyemia. Such a condition of the jugular shows itself as a tender cord-like swelling, deeply situated along the sternomastoid. The lateral sinus has been frequently opened and septic clots removed with or without previous ligation of the internal jugular.

The Eustachian tube, like the external auditory canal, is comprised of bony and cartilaginous portions. It is lined by mucous membrane continuous with that of the middle ear at one end and with that of the nasopharynx at the other. Nasal catarrh frequently spreads along it to the middle ear. It can be inflated by inserting a catheter into its opening just behind the posterior nares on the lateral wall of the nasopharynx (see Figs. 12, 17, and 19).

The **internal ear** is so compact and so deeply situated that it is not accessible to any operative intervention. In certain diseases (Ménière's) there is marked vertigo, due to a disturbance of its semicircular canals. In addition to these canals, which with the cerebellum have as their probable function the regulation of equilibration, it contains the end-organs of the auditory nerve in the cochlea. Deafness due to disease of these is not amenable to treatment.

**The Face.**

The lower boundary of the face is the lower border of the lower jaw and a line continued to the apex of the mastoid process behind. The upper boundaries are the supra-orbital ridges and a line continued from the outer end of each along the upper border of the corresponding zygoma to the little cartilage on the front of the ear (the tragus).

**Examination of Face during Life.**—1. Palpate the lower margin of the orbit at the junction of its inner and middle thirds and feel the notch for the transmission of the infra-orbital vessels and nerve (see Fig. 30). Pressure upon this causes a dull pain to be felt over the upper jaw. Draw a vertical line downward from the supra-orbital notch noted above. This line passes directly through the infra-orbital notch, and as it crosses the lower jaw one can feel a third notch, the mental foramen, through which the mental nerve emerges, so that the three principal cutaneous branches of the fifth nerve all lie close to the skin in one straight line. It is important to remember their position in testing for neuralgia of the corresponding branch of the fifth nerve.

2. Passing the fingers outward along the infra-orbital margins, note the prominent malar bone. It is continuous behind with the zygoma.

3. Palpate the entire zygoma again and note how it is formed partly by the termination of the temporal ridge from the external angular process of the frontal bone and partly by the zygomatic process of the malar bone. It becomes much thinner as it passes backward toward the ear. At its posterior end feel the pulsations of the temporal artery.

4. Immediately below the zygoma one can feel beneath the skin and in front of the ear a soft structure, the parotid gland (Fig. 30). It is readily movable upon the underlying masseter muscle, which can be distinctly felt when the lower jaw is brought firmly against the upper. The anterior border of the muscle is especially well marked. At the junction of this border with the lower border of the lower jaw note the pulsations of the facial artery. Just in front of the ear and a little below the posterior end of the zygoma, one can feel the movements of the condyle of the lower jaw when the mouth is opened and closed. This corresponds to the situation of the temporomaxillary joint (see Fig. 31).

5. Passing the fingers along the body of the lower jaw, note the prominent anterior portion, or symphysis mentis, and observe how much thicker the skin is here than it is over any other portion of the face, except the parotid region. Feel the ridges just above the lower border of the lower jaw, due to the roots of the various teeth. Note the naso-labial fold, a slight groove, passing from the outer edge of the nostrils in a curved manner to the angle of the mouth (see Fig. 20). Observe

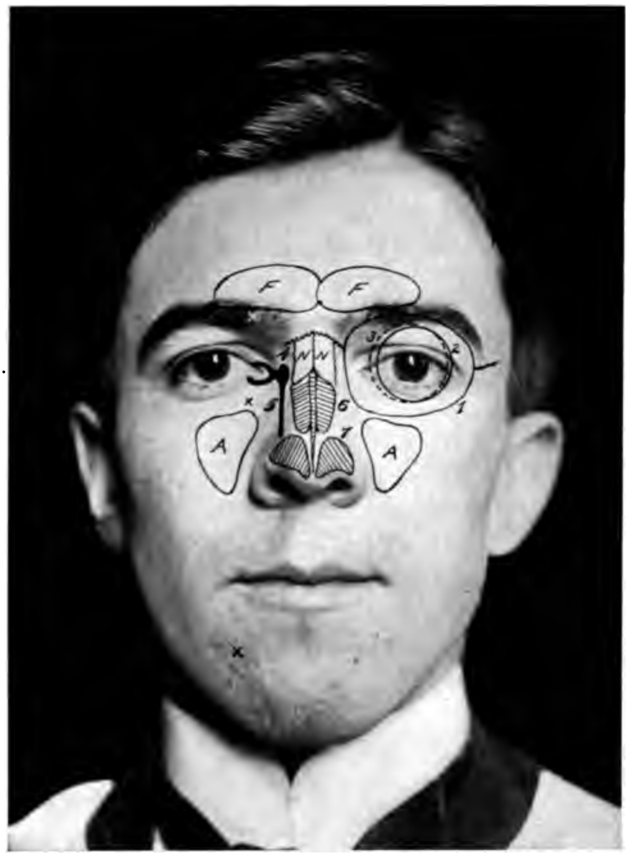


Fig. 20.—Relation of accessory sinuses, nasal bones and cartilages, canaliculi and nasal ducts, and sac to surface. Projection upon surface of outer margins of orbital cavity, of conjunctival sac, and of globus oculi upon surface. A, Antra of Highmore. F, Frontal sinuses. The white cross above the right upper lid shows the relation of the supra-orbital nerve to the frontal sinus. The black cross just beneath the lower lid indicates the relation of the infra-orbital nerve to the antrum. N, Nasal bones. 1, Projection of margin of orbit upon surface. 2, Projection of eyeball (globus oculi) on surface. 3, Projection of conjunctival sac upon surface. 4, Lachrymal sac. 5, Nasal duct. From the lachrymal sac to the inner ends of both eyelids the lachrymal canals can be seen terminating at the eyelids in the puncta lachrymalia. 6, Lateral cartilage of nose. Between the cartilage of each side (indicated by transverse lines) is the cartilaginous portion of the septum, upon which they rest. 7, Alar cartilages.

the movements of the muscles of expression: the depressors and levators of the lips, the circular muscle of the mouth, the dilators and compressors of the nostrils, the circular muscle of the eyelids, and those which raise the eyebrows.

6. Observe the contour of the lips and the depression in the center of the upper lip, known as the filtrum. The demarcation between the red mucous membrane of the lips (vermilion border) and the skin of the face is quite sharp. Palpate the body of the upper jaw on each side below the infra-orbital margin and malar bone; note again the prominences due to the roots of the teeth. Just above one of these, running upward from the canine tooth on each side, is a ridge known as the canine ridge or eminence, above which lies the antrum of Highmore (Fig. 20).

7. Just below the glabella palpate the two small nasal bones and note that they extend downward only as far as the level of the inner canthus of the eye (Fig. 20). From this point downward palpate the lateral cartilages of the nose, which form the lower portion of its roof. Note how they are separated in the median line by the cartilaginous septum. They do not extend down to the lower border of the nose, but only about half-way. Palpate, in the median line again, the cartilaginous septum and observe that it extends almost to the tip of the nose. Take up the wings or alæ nasi between the fingers; note how elastic they are, due to the more flexible triangular cartilages which give them their form. Observe at the same time the fact that the skin over the nose is not very elastic and is very thin.

In children, on account of the lack of development of the accessory sinuses of the nose, the bones of the face are less prominent than in the adult. In both children and old people—owing, in the case of the former, to the nondevelopment of the teeth, and in old people to atrophy—the lower jaw is to be felt as a mere strip of bone.

The face can be divided into two regions—an anterior and a lateral. The former includes all of that portion which lies below the supra-orbital ridges, above the lower border of the lower jaw, and in front of a line drawn on each side from the malar bone downward. The lateral or parotid region is bounded by the just mentioned line in front, by the zygoma above, and by the lower border of the lower jaw and its continuation to the tip of the mastoid process behind.

**Anterior Portion, or Face Proper.**—The skin is finer and more elastic than that of the scalp or of the parotid region. It contains a large number of sebaceous glands, especially around the alæ nasi and the angles of the mouth, which are frequently the seat of acne. The subcutaneous tissue is loosely arranged, and permits of great swelling,

especially around the eyes and lips, either as a result of infection or of any form of edema due to a systemic disease—for example, nephritis.

The skin is so elastic that it is well adapted for plastic operations. These must frequently be performed in the correction of congenital malformations, such as hare-lip,etc., or for the deformities due to cicatrices, the result of burns, of cancrum oris (a form of gangrene of the cheeks following marasmus and measles), or the removal of tumors.

Immediately beneath the skin and intimately attached to it are the muscles of expression. These are separated from it only by a layer of fat, which is most abundant over the buccinator. They are all supplied by the seventh or facial nerve, and may be divided into three groups (see Figs. 10 and 30):


Fig. 21.—Facial paralysis of left side. 1, Bilateral attempt to raise eyebrows; 2, bilateral attempt to close eyes; 3, smiling (Church).

1. Those which open and close the eyelids and raise the eyebrows —namely, the eye group.
2. Those which dilate or contract the nostrils—the nasal group.
3. Those which open and close the lips or depress the angles of the mouth—the buccolabial group.

In a paralysis of the seventh nerve distal to its exit from the brain all three groups are involved. This is spoken of as a peripheral form, and may be due to injury or disease of the facial nerve either during its passage through the temporal bone or after the nerve leaves the stylomastoid foramen. In this peripheral form the nasolabial fold is effaced, the angle of the mouth on the paralyzed side droops, and the eyelids do not close, thus leaving the eyeball exposed (lagophthalmus). When the patient is asked to smile or show his teeth, the paralyzed side remains motionless (see Fig. 21).

In the central form only the two lower groups—the nasal and bucco-labial—are paralyzed, so that the eyelids can be opened and closed, but the muscles of the lips cannot be moved, and the breathing, if the patient is unconscious, is stertorous, owing to the paralysis of the buccinator, which permits the cheek on the paralyzed side to be blown outward during expiration.

It is not quite clear why there should be a difference between a central and a peripheral facial paralysis, from an anatomic standpoint. It is probably due to the fact that the fibers of the facial, which supply the muscles of the eyebrows, etc., are derived from another cranial nerve

Fig. 22.—Double hare-lip and cleft palate. The prominence on the left side of the deformity shows the protruding intermaxillary bone, with the skin of the median line of the lip covering it (skin of frontonasal process).

and enter into the formation of the facial after it leaves the brain, so that hemorrhage into the internal capsule or into the pons—that is, any lesion affecting the facial nerve prior to its exit from the brain—affects only the two lower groups; whereas, any condition involving the nerve after its exit from the brain affects the three groups.

A frequent deformity in connection with the upper lip is hare-lip (Fig. 22). It is often associated with a cleft palate. The palate is formed in the embryo by the union, in the median line, of two processes—the superior maxillary on each side, offshoots of the first branchial or mandibular arch, and the fronto-nasal process. When they fail to unite, a gap or defect is left which may be exactly in the median line, or lateral

to it (cleft palate). The skin covering these bony processes may also fail to unite, and a similar defect occurs in the upper lip (hare-lip). The latter is most frequent on the left side, extending into the nostrils, but it may be bilateral. It may or may not be associated with a cleft palate.

In the illustration the inter- or premaxillary bone, which corresponds to the lowermost portion of the nasofrontal process, is seen deviated toward the left, and covered by the skin corresponding to the same process.

The **lips** are covered with a mucous membrane which is continuous with that of the mouth. The color of the lips is a direct reflection of the condition of the circulation, except in those who have been exposed to the vicissitudes of the weather. When oxygenation is deficient, they are bluish or cyanotic. Under normal conditions they are of a bright reddish color. In conditions of anemia they, like the other visible mucous membranes,—for example, the conjunctivæ, palate, gums, etc., —are of a whitish color. Their junction with the skin of the face is a frequent seat of epithelioma, especially in the lower lip.

Carcinoma is not infrequently found in the human body, where one variety of epithelium undergoes transition into another. Malignant processes are very apt to begin here, owing, probably, to the inclusion of a certain number of cells at the junction of the two varieties (lips, cervix uteri, anus, cardiac end of stomach).

A form of skin eruption known as herpes is often seen around the corners of the mouth, consisting of a group of fine vesicles. Extra-genital chancres must always be thought of when a firm, hard, slightly excavated ulcer is situated upon the lips. The frequency of slight fissures or cracks here offers a favorable atrium for syphilitic infection.

The chief vessel supplying the skin and underlying tissues of the anterior region is the **facial artery** (see Figs. 30 and 31). Its course is represented by a line drawn from the anterior border of the masseter muscle (at its attachment to the lower jaw) to the inner angle of the orbit. It gives off branches to the lips (coronary), side of the nose, etc. Its anastomoses are so free that infection rarely follows a wound of the face, and even the most extensive incisions heal by first intention.

The artery is accompanied by the **facial vein,** which receives blood from the orbit (ophthalmic vein) and the face. In severe cases of infection, especially in furuncles, of the upper lip, it may become the seat of a septic thrombophlebitis, which can extend inward to the cavernous sinus, or downward into the external jugular, into which it empties.

The **nerve-supply** of the anterior region is derived from the fifth and the seventh nerves. The former furnishes all of the nerves of sensa-

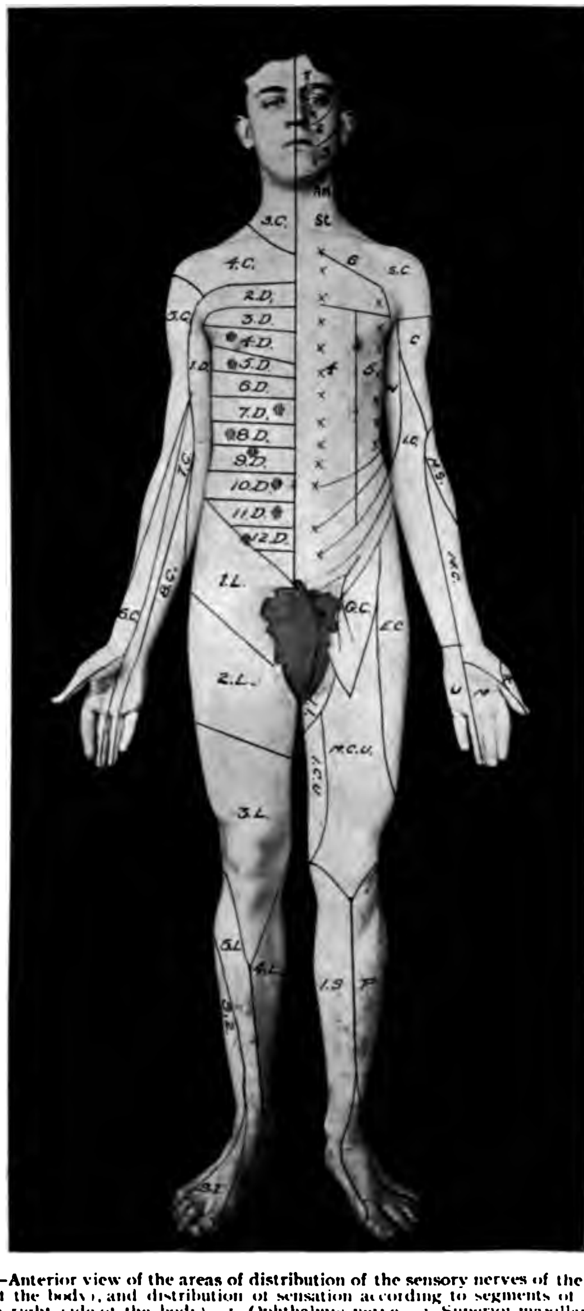


**Fig. 23.**—Anterior view of the areas of distribution of the sensory nerves of the skin (shown on the left side of the body), and distribution of sensation according to segments of the spinal cord shown on the right side of the body). 1, Ophthalmic nerve. 2, Superior maxillary nerve. 3, Inferior maxillary nerve. The points of exit of the supra-orbital, infra-orbital, and mental nerves are shown by the markings - . 4, Points of exit of the anterior intercostal branches of the intercostal nerves. 5, Points of exit of the lateral branches of the intercostal nerves. 6, Intercosto-humeral nerve. A.M. and S.C., Area of distribution of the great auricular, superficial cervical, and supra-clavicular branches of the cervical plexus. C, Circumflex nerve. W, Nerve of Wrisberg. I.C., Internal cutaneous area. M.S., Musculospiral area. M.C., Musculocutaneous area. U, Ulnar. M, Median. R, Radial. G.C., Genitocrural area. The nerve is seen as distributing its branches to the genital region and to the upper portion of the thigh. E.C., External cutaneous area. I.I., Ilio-inguinal area. I.C.U., Internal cutaneous area of the thigh. M.C.U., Middle cutaneous of thigh. I.S., Internal saphenous. P, External popliteal branches area. On the right side the division according to segments is seen, the letters C, D, L, and S standing respectively for cervical, dorsal, lumbar, and sacral segments of the cord. On the right side, from the fourth dorsal to the twelfth dorsal (inclusive), the maximum points, according to Head, of the abdominal viscera are shown in relation to the spinal segments. (See Abdomen.)


Fig. 24.—Coronal section of skull to show frontal sinuses and antra of Highmore. 1, Frontal sinuses. On the right side a probe is seen, indicating the position of the opening of this side. 2, Antra of Highmore. On the right side a probe is seen, indicating its opening into the middle meatus. Upon the left side the communication referred to in the text as occasionally existing between the ethmoidal cells and the antrum is shown by the probe. 3, Ethmoidal cells. 4, Middle turbinated bone. 5, Inferior turbinated bone. 6, Deviation of septum to right. 7, Hard palate. 8, Globus of eye. 9, External rectus muscle. 10, Inferior rectus muscle. 11, Internal rectus muscle. 12, Superior oblique and superior rectus muscles.

tion; the latter, those of motion. The ophthalmic branch of the fifth supplies the upper third (forehead), the superior maxillary the middle, and the inferior maxillary the lower third (see Fig. 23) through their supra-orbital, infra-orbital, and mental branches respectively. The foramina of exit, as mentioned above, are in one straight line (see Fig. 30) drawn from the junction of the inner and middle thirds of the supra-orbital margin downward. The **lymphatics** close to the median line drain into the submental; those more laterally into the submaxillary glands (see Fig. 4).

The **bones of the face** lie immediately beneath the skin, which is freely movable on them. The principal ones are the upper and lower maxillæ, the nasal and malar bones. The malar bones serve as buttresses, and are compactly formed so as to resist force coming from that side. Under conditions of emaciation, when the normal mass of fat beneath them in the cheek disappears, they become very prominent.

The superior and inferior maxillæ serve principally as supports for the teeth, and assist in the mastication of food. The superior maxilla forms a portion of the orbital and nasal cavities, and would be a very bulky bone were it not for the large cavity which it contains, the antrum of Highmore (Fig. 20). This latter is lined, like the frontal sinus, by a mucous membrane continuous with that of the nose, and opens into the middle meatus (see Figs. 12, 17, 24, and 29), close to the orifice of the frontal sinus. Its opening is situated about midway between its floor and its roof, so that the conditions for drainage are poor.

It is frequently involved, through extension of infection from the nose (empyema of antrum), and filled with a mucopurulent secretion. The poor natural facility for drainage often renders it necessary to drain the antrum by other means. For this purpose advantage is taken of the fact that the first molar tooth roots often project into the floor of the antrum, and the extraction of this tooth gives free drainage. The anterior wall of the antrum is a very thin shell of bone, corresponding to a ridge above the canine tooth (canine eminence), and the antrum can be opened by lifting up the cheek and chiseling through this thin plate after incising and pushing back the periosteum of the upper maxilla.

The malar bone and superior maxilla are rarely broken, owing to the density and protection which the former gives and the rather deep position of the main portion of the upper jaw. There is seldom any displacement. A fracture may vary from a fissure to extensive comminution.

Fractures of the lower jaw are more common, especially of its body. They are most frequent at or near the median line (Gurlt), due to the

rather marked weakening which the mental foramen causes. The fracture is often bilateral, and if so, symmetrical. Not infrequently the fracture communicates, through a tear in the mucous membrane, with the cavity of the mouth, and thus becomes a compound fracture. Infection of the fragments is scarcely avoidable, resulting in the formation of abscesses which open externally either over the jaw itself or in the submaxillary region of the neck. The alveolar processes are sometimes broken during the extraction of teeth.

**Tumors** are often primary in the jaws, especially sarcoma. Carcinoma of the superior maxillary often has its starting-point in the mucous membrane of the antrum. Sarcomata of the jaws grow very rapidly, owing to the rich blood-supply, and may become of enormous size. Their removal usually involves a partial or complete resection.

### Lateral or Parotid Region.

This portion of the face contains some very important structures, whose relation to the surface may be seen in figures 5, 10, 30, and 31.

The region is bounded by the ear behind, by the zygoma above, a line drawn from the malar bone downward in front, the lower border of the inferior maxilla, and a line continued to the mastoid, below. The skin covering it is firmer and less elastic than that of the anterior region or face proper. The underlying muscles are not attached to the skin, as in the anterior region. The region may be divided into two layers—the superficial, including all of the structures external to the ramus of the jaw; the deeper, all of those internal to the same.

In the superficial layer lies the **parotid gland,** which is triangular in shape, with base upward, the greater part of it being situated between the condyle of the lower jaw and the cartilaginous auditory canal (Figs. 5 and 30). It contains within its capsule several lymphatic glands which drain the anterior region of the scalp. The parotid gland is inclosed in a firm fascia (parotid), which is almost continuous except toward its inner aspect, where it communicates with the connective tissue of the pharynx. Hence, parotid abscesses are under great tension, and may rupture toward the pharynx or occasionally into the external auditory canal. The gland has passing through it the facial nerve, the termination of the external carotid artery, the beginning of the external jugular vein, and the auriculotemporal nerve. The artery divides into (see Figs. 5 and 31) two terminal branches opposite the condyle, the internal maxillary and the superficial temporal. The **facial nerve** divides, inside the gland, into a larger number of branches which perforate the capsule on its anterior and upper borders, forming the pes anserinus

(Figs. 10 and 30). From about the middle of the anterior border of the gland its duct (Steno's) passes forward about a finger's-breadth from the zygoma across the masseter muscle, to turn around the anterior border of this muscle and enter the mouth opposite the second upper molar tooth (Fig. 30). The beginning of the external jugular vein also lies in the gland.

The fact that all of these important structures lie within the gland renders it necessary to employ some blunt method like that of Hilton-Roser in opening abscesses. In cases of operation for tubercular glands of the neck, some of which may be imbedded in the gland substance, or in the removal of tumors of the gland, these structures must be borne in mind, or a facial paralysis or salivary fistula will follow.

In all forms of inflammation of the gland the ear is raised upward and away from the head, owing to its proximity. Islands of embryonal cartilage from the first or mandibular arch often remain inclosed within the parotid gland which surrounds the upper end of the arch. In later life they may give rise to the most frequent forms of the tumors of the parotid, the chondromata, chondrosarcomata, and various forms of the so-called mixed tumors.

The epidemic form of parotitis (mumps) is frequently complicated with a metastasis in the testis in males (orchitis) or in the ovary in females (oöphoritis). This can only be explained on the theory of its being a general infection, and not upon any anatomic connection.

The only other structure in the superficial layer is the masseter muscle, upon which the parotid lies in part. It is to be felt during mastication as a firm ridge from the zygoma to the lower border of the lower jaw. It is supplied by the motor root of the fifth nerve, and may be reflexly contracted whenever any of the sensory branches of the same nerve are irritated in the mucous membrane of the mouth or the teeth. This condition is called symptomatic lockjaw, and frequently occurs, especially in adults, during the eruption of the third molar or wisdom tooth, in inflammations of the gums or mouth, and in carious conditions of the teeth. A removal of the cause disturbing the sensory or afferent branch of the reflex arc will quickly cause a relaxation of this form of reflex spasm.

In tetanus, formerly called idiopathic lockjaw, the contraction of the masseter is an early symptom. The patient is unable to open the mouth on account of the firm spasmodic tonic contractions of the masseters and pterygoids.

Between the superficial and deeper layers of the parotid region lies **the ramus of the jaw.** Its outer aspect is covered by the masseter

muscle and parotid gland. Its coronoid process has attached to it the tendon of the temporal muscle. Its condyloid process articulates with the temporal bone (temporomaxillary joint), whose relation to the surface is shown in figure 30). Its proximity to the auditory canal has already been mentioned.

The force of blows or falls upon the chin is transmitted through this articulation (which is in close relation to the floor of the middle fossa) to the skull, and may cause either concussion of the brain or fracture of the base of the skull. The joint is more frequently than was formerly believed the seat of either a simple (rheumatic) or a suppurative (pyemic) synovitis, the latter especially in gonorrhea. The pain is felt in front of the ear during movements of the lower jaw. Ankylosis of the joint following such inflammations may occur, necessitating resection. Occasionally the joint is drained through an incision made directly over it, care being taken to avoid all the structures lying in the parotid gland.

In the **deep layer of the parotid region** lie the internal maxillary artery, the second and third branches of the fifth nerve, the external and internal pterygoid muscles, and, in addition, separated from it by the bone of the middle fossa, the Gasserian ganglion of the fifth nerve. Their relation to the surface may be understood from a study of figure 30.

The external pterygoid muscle is inserted close to the condyle of the jaw. When the mouth is opened widely, this muscle may, by its sudden contraction, pull the condyle across the eminentia articularis, and produce practically the only variety of dislocation of the lower jaw which occurs—the forward or anterior. From this knowledge of the mechanism the reduction of such a luxation is easy. The thumbs (well protected, so as to avoid being cut with the teeth) are inserted into the mouth and pressure made downward over the lower molars. The condyle is thus brought under the eminentia articularis and quickly slips past it into the joint.

The chief branch of the internal maxillary artery which is of clinical interest is the middle meningeal artery, which ascends to the middle fossa, entering it through the foramen spinosum (see Figs. 8, 11, 12, and 14). The other structures which for topographic purposes can be considered in the deep layer of the parotid region, are the second and third branches of the trigeminal nerve and the sphenopalatine or Meckel's ganglion (see Fig. 10). The superior maxillary, or second branch, passes directly into the upper jaw, sending filaments to the teeth and forming the infra-orbital nerve.

(*a*) The lingual, which passes on the inner side of the ramus to the floor of the mouth;

(*b*) The auriculotemporal which penetrates the parotid to supply sensation to the side of the head; and into

(*c*) The inferior dental, which enters the inner side of the ramus of the jaw and supplies the lower teeth and ends in the mental nerve. In the old operation of Rose, which consisted in resecting the superior and inferior maxillary nerves for incurable neuralgia, these nerves were resected shortly after their exit from the skull. At the present time this operation has been superseded by either the Krause-Hartley or the Cushing operations. Neuralgia of the branches of the fifth cranial nerve may involve one or all three principal nerves which arise from it. The affection is called "painful tic" (tic douloureux) or trigeminal neuralgia, and the exits of these three branches on the face are found on pressure to be painful (see Anterior Region of Face). This may become so severe as to necessitate the removal of the Gasserian ganglion. The relations of the latter will be understood by referring to figures 8, 10, and 17. It can be removed by a flap made over the temporal region (Krause-Hartley), or by resecting the zygoma temporarily and chiseling nearer the base of the skull (Cushing). The latter has the advantage of avoiding the middle meningeal artery. In removing the ganglion during this operation care must be taken (see Fig. 10) not to injure the cavernous sinus and internal carotid artery on the inner side, and the third, fourth, and sixth nerves.

## The Mouth, Pharynx, and Larynx.

(The anatomic and clinical relations of these three important divisions of the head to each other and to the nasal cavity can be understood by reference to figures 12, 19, 25, and 26. At the same time, it is of the utmost importance to examine one's own mouth and pharynx and utilize every opportunity in the clinic-room to make a laryngoscopic and posterior rhinoscopic examination of normal individuals.)

**The mouth** can be divided into two parts: The vestibule, which lies in front of the teeth; and the buccal cavity proper, behind them (Fig. 26).

The **vestibule** has opening into it, opposite the second upper molar tooth, the orifice of Steno's duct, from which, by pulling the cheek outward, one can see saliva discharged in spurts, from time to time. In patients like those suffering from typhoid fever, who are in such a lethargic condition that food particles and organisms can accumulate in the vestibule, especially on the gums, it can be readily understood how germs can travel upward along the duct and cause a suppurative paro-

titis. This complication is far less frequent at present, since the care of the mouth has been insisted upon during typhoid fever.

In examining the vestibule do not neglect to palpate the upper and lower reflections of the mucous membranes upon the jaws, and note the outer surfaces of the latter, especially a depression above the canine tooth eminence, which is the anterior wall of the antrum (Fig. 20). On the inner side of both lips a number of pearly, minute elevations can be seen, the buccal glands, which may become occluded and form small cysts containing a clear mucus.

The **teeth** separate the vestibule from the mouth cavity proper (see Fig. 26). They are inserted into excavations in the jaws called alveoli, which are lined by a periosteum continuous with that covering the remainder of the jaws, but much thinner and tougher. At the margin of the alveolar cavity this periosteum is also continuous with the **gums,** as the mucous membrane of the mouth covering the alveolar processes close to the teeth is called. The gums are firmer than the remainder of the mucous membrane, and help to fasten the teeth; hence, they must be pushed aside prior to the extraction of teeth. The gums are very vascular and bleed readily, and are directly continuous with the periosteum of the jaw; hence, abscesses beneath them (gum-boils) are under great tension and are very painful. Foreign particles readily accumulate at the junction of the gum and tooth, serving as pabulum for the many organisms so constantly present in the mouth, and causing either an inflammation of the gums alone (gingivitis) or of the entire buccal cavity (stomatitis). Such conditions are especially frequent in marantic, badly-cared-for children, or, in general, when care is not taken to remove this accumulation frequently. In patients taking mercury a most violent stomatitis may occur as the result of a neglect of this detail. It is due, no doubt, to the fact that a small amount of certain metallic substances, like lead, mercury, and phosphorus, are excreted through the gums and are deposited at their edges. This explains the so-called black line at the junction of the gums and the teeth, in lead-poisoning, and also the extensive destruction of the alveolar processes in phosphorus-necrosis, caused by the inhalation of phosphorus-fumes.

The teeth are: the temporary or milk teeth, which appear in infants at the age of seven months, and begin to be replaced by the permanent teeth at the age of seven years. The order of eruption of these milk or deciduous teeth should be borne in mind:

The middle incisors, sixth to eighth month.

Lateral, eighth to twelfth month.

First molars, twelfth to sixteenth month.


Fig. 25.—Sagittal section of child's body (Rüdinger). 1, Cartilaginous portion of septum; behind it the bony portion is seen. (Vomer and rostrum of sphenoid.) 2, Thyroid gland, showing relatively large size of same in child. 3, Thymus gland, showing how an enlarged thymus may cause pressure upon the trachea and vessels at lower portion of neck. 4, Tongue in sagittal section, showing how paralysis of muscles at base of tongue will cause this organ to fall back upon the epiglottis lying immediately behind it and thus cause cyanosis during anesthesia by closure of the glottis. 5, Nasopharynx. 6, Liver, showing relations of this organ to diaphragm and pericardium above it, and transverse colon and duodenum below it. 7, Ampulla of rectum, below which the rectum narrows to form the anal portion of the rectum. 8, Bladder and urethra. It will be noted that in the child the greater portions of the rectum and bladder lie in the abdomen, the pelvis itself being quite primitive. Note also the sharp upward curve of the urethra.

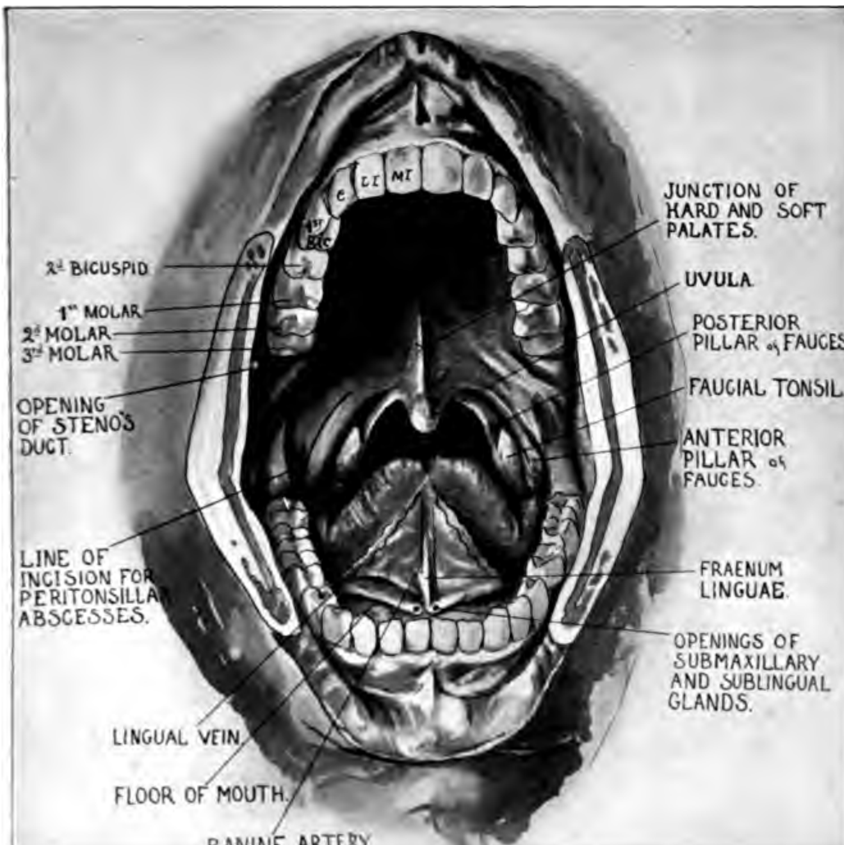


**Fig. 26.—View of adult mouth (modified from Spalteholz). M.I., Middle incisor. L.I., Lateral incisor. C, Canine tooth. 1st Bic., First bicuspid tooth.**

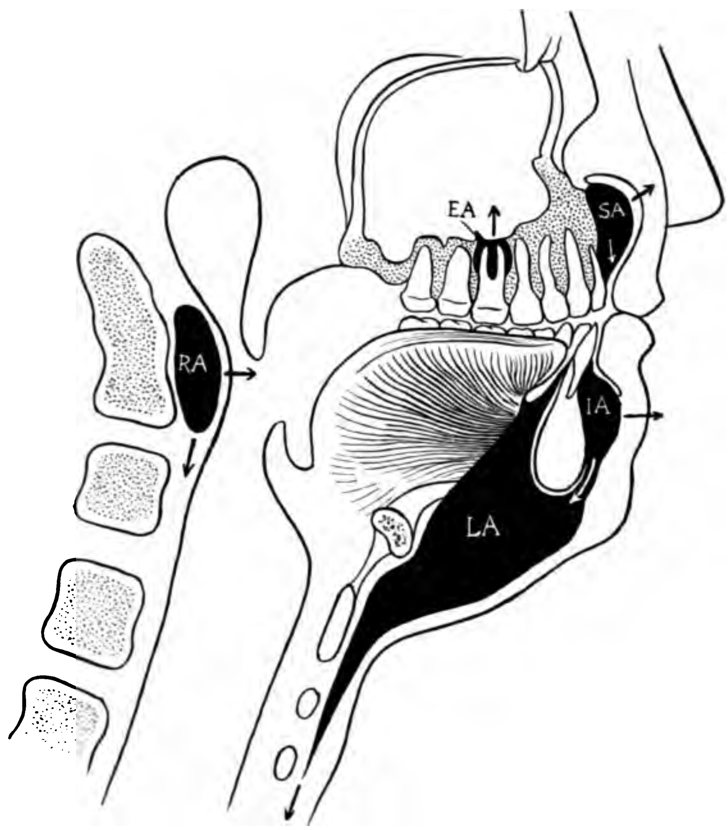


Fig. 27.—Sagittal section of head to show spread of suppuration from infected teeth; and also location of retropharyngeal abscesses. SA, Subperiosteal abscess of upper jaw opening toward cheek and mouth in direction of black and white arrows, respectively. IA, Subperiosteal abscess of lower jaw opening toward submaxillary region and chin in direction of white and black arrows, respectively. LA, Infection in submaxillary subcutaneous tissue as a result of abscesses arising from teeth and from floor of mouth. (This condition is also called angina Ludovici.) EA, Infection around roots of bicuspid and molar teeth spreading toward antrum in direction of arrow. RA, Retro-pharyngeal abscesses.

Canine teeth, fifteenth to twentieth month.

Second molars, twentieth to thirtieth month.

The teeth of the lower jaw generally precede those of the upper.

There are only twenty milk or deciduous teeth, and these are gradually replaced by the permanent teeth after the age of seven years. These are thirty-two in number, the additional ones being the first and second bicuspids and a third molar.

The teeth are supplied by branches of the fifth nerve, those for the upper jaw being derived from the superior maxillary branch of the fifth, and those for the lower jaw from the inferior dental branch of the inferior maxillary division of the fifth (Fig. 10).

Not infrequently carious teeth, or similar processes in the alveolus, are the starting-point of an obstinate neuralgia, at first affecting only the corresponding branch of the trigeminal but gradually affecting all three branches, so that it is necessary to resect either one of the main trunks supplying the upper and lower jaws, or even to resect the Gasserian ganglion itself. If obstinate (so-called tic douloureux), a neuralgic condition of the entire fifth nerve exists.

As was stated before, infective inflammations of the gums, not infrequently associated with the eruption of the third or wisdom tooth, may give rise to a spasmodic contraction of the masseter muscle, in which the sensory branches of the fifth, supplying the teeth and gums, act as the afferent, and the motor root of the fifth as the efferent side of the reflex arc, the motor root supplying the pterygoids and masseter muscle. This spasmodic contraction is often so severe as to require the actual prying apart of the jaws in order to gain access to the wisdom tooth.

The **palate** is divided into the soft and hard palates, the latter beginning at the posterior surface of the teeth and extending the entire length of the palatal processes of the superior maxillæ and palate bones. The mucous membrane of the palate is so closely adherent to the periosteum as to form one membrane. This fact is taken advantage of in the repair of the congenital defect known as cleft palate. This congenital defect is similar in origin to that of hare-lip. In the same manner as was seen in the case of hare-lip, the failure of the bony portions of the frontonasal and superior maxillary processes to unite gives rise to a gap along the line which should correspond to their point of union, and this gap is either unilateral or bilateral. If unilateral, it is most frequent on the left side; if bilateral, it is very frequently associated with an intermaxillary bone, as in figure 22, and the two gaps or clefts are separated by the vomer. In order to repair this defect two anatomic points are taken advantage of:

1. That the palate is chiefly nourished by the posterior palatine artery which lies close to the alveolar processes. Hence, to loosen the flaps before suturing them the incision is made parallel to the alveolar processes, so that the artery is included in the posterior end of the flap.

2. Knowing that the mucous membrane of the hard palate is closely united with the periosteum, it is stripped off or loosened from the bone, except at its anterior and posterior ends, where the corresponding palatine arteries enter to nourish the flaps. The flaps from each side are then brought together in the median line and united. The periosteum readily forms new bone and the gap is then bridged.

The mucous membrane of the palate, both soft and hard, frequently shows changes during the course of both acute and chronic diseases. The eruption of measles can frequently be seen here, prior to its appearance elsewhere. Its deep injection in the early stages of scarlatina is always of diagnostic value. Jaundice often shows itself near the junction of the hard and soft palates by a yellowish tinge, when but slightly marked in other parts of the body. The junction of the soft and hard palate is a frequent location for gummata in the tertiary stage of syphilis.

That portion of the soft palate which hangs in the median line is called the **uvula.** It is formed by the union of four folds or curtains of mucous membrane, the two in front being called the anterior pillars and those behind the posterior pillars of the fauces (see Figs. 19 and 26).

The soft palate can be raised and made tense by two muscles, the levator and tensor palati (Fig. 19). These muscles frequently cause the edges of a cleft palate to be forcibly separated, and were formerly frequently divided through an incision half-way between the hamular process and Eustachian tube and perpendicular to a line drawn between them.

Clefts of the soft palate may occur independently of those of the hard palate. At times the soft palate or uvula may be so elongated and swollen that it hangs down, touching the epiglottis, and at times even dropping into the entrance of the larynx, giving rise to severe attacks of paroxysmal cough, whose nature cannot be understood until the condition of the palate has been thought of as a cause.

Between the pillars of the fauces above spoken of are situated the **faucial tonsils,** as distinguished from the pharyngeal or Luschka's tonsil, which will be spoken of below. These tonsils vary greatly in size, and are composed of lymph-tissue covered with mucous membrane continuous with that of the mouth and pharynx. They contain a considerable number of pocket-like inversions of the mucous membrane, called follicles, in which debris frequently collects; and they are

the seat of a variety of inflammation known as follicular tonsillitis. The tonsils are also a favorite location of diphtheritic processes, this disease causing an actual necrosis of the mucosa. At times in follicular tonsillitis, the organisms may migrate through the mucous membrane into the submucous tissue, and give rise to a peritonsillar abscess, or quinsy. Such an inflammation will cause extensive edema of the loose connective tissue of the soft palate and pillars of the fauces, and may even extend, unless relieved by incision, to the submucous tissue of the larynx as far as the vocal cords, causing an edema of the glottis, and, in some cases, asphyxiation as a result of the latter.

The tonsil is supplied by a branch of the ascending palatine artery, and at times by a branch of the facial artery. As will be seen in the section on the submaxillary region of the neck the facial artery may at times dip in so deeply as to be caught tangentially by the tonsillotome, and severe hemorrhage result. The internal carotid artery lies a sufficiently great distance from the tonsil to be ignored as a source of severe hemorrhage after tonsillotomy. The least dangerous place to open the abscess of the peritonsillar tissues is by an incision made parallel to the anterior pillar of the fauces (see Fig. 26).

The space between the anterior pillars of the fauces on each side is known as the isthmus of the fauces. At times the tonsils may be so hypertrophied and swollen as to almost meet each other in the median line, entirely filling the isthmus.

On the **floor of the mouth,** to each side of the median line, corresponding to two fringes of mucous membrane which meet at the tip of the tongue, are the ranine arteries (see Fig. 26). In the median line at the junction of the tongue with the floor of the mouth are two papillæ which correspond to the openings of the ducts of Wharton; a little more externally is the orifice for the duct of the sublingual gland. Passing from the floor of the mouth to the under surface of the tongue is a whitish fibrous band in the median line, known as the frenum of the tongue. In infants this is at times exceedingly short (tongue-tied), and must be cut. Great care must be taken to lift the tongue upward in order not to wound the ranine artery. The best method of doing this is to place the frenum in the notch at the broad end of a grooved director and hold the latter against the tongue, dividing the frenum below it. The base of the tongue at the junction with the floor of the mouth is a frequent seat of dermoid cysts and also of a benign tumor known as ranula, due to obstruction of the ducts of the sublingual and submaxillary glands. A little more externally, opposite the molar teeth, just beneath the mucous membrane, lies the lingual nerve (see Figs. 10 and 12).

The **tongue,** for practical purposes, can be considered as a solid muscular organ, although it is composed of two sets of muscles: (1) The extrinsic, such as the hyoglossus and styloglossus, which pull the tongue backward, and the genioglossus, which pulls the tongue forward; and (2) the intrinsic muscle, or lingualis, which causes change in the contour of the tongue.

These muscles are all supplied by the hypoglossal and chorda tympani nerves. The mucous membrane covering the tongue is very thin on its inferior aspect, but much thicker on the upper surface. Scattered all over the dorsum are a number of filiform papillæ. Between these, along the edge of the tongue, are the fungiform, which are enlarged in scarlet fever, giving rise to the strawberry tongue of that disease, which appears about the third or fourth day; and at the root of the tongue, which is the portion nearest the larynx, there is a row of large papillæ on each side, known as the circumvallate papillæ (see Fig. 19).

There are many mucous glands over the tongue, especially at its base or root, and at the tip on each side of the frenum. The collection of adenoid tissue at its base, just behind the circumvallate papillæ, is called the lingual tonsil. Its enlargement may be a frequent cause of irritating cough (see Fig. 19).

The mucous membrane of the tongue, as well as that of the mouth, is the seat of a disease known as psoriasis, which shows itself by whitish plaques. When the muscles of the tongue are paralyzed or lose their support (for example, after the resection of the lower jaw), the tongue may fall backward and obstruct the entry of air into the larynx. When this happens in chloroform anesthesia, the tip of the tongue must be brought forward with a special forceps; or the same can be accomplished by lifting the jaw upward and forward by grasping it at its angle.

The tongue receives its blood-supply from the lingual artery. Wounds of this organ bleed readily, but the hemorrhage is easily checked by transfixion. The lingual vein accompanies the artery throughout its course, and the radicles of this vein are especially numerous along the inferior surface. The tongue is exceedingly richly supplied with lymph-vessels, draining into the submaxillary and deep cervical glands; hence, the spread of carcinoma is favored.

Infection of the tongue, or glossitis, causes great swelling of the organ, on account of the large amount of connective tissue between the muscles. The sensory nerves of the tongue are the lingual, which supplies it with general sensation, and the glossopharyngeal, which supplies it with the sense of taste. Macroglossia is the name given to a large tongue, due to the presence of a lymphangioma. The under sur-

face of the tongue, as well as the inner surface of the cheeks and the pillars of the fauces, may be the seat of a cavernous hemangioma.

**The Pharynx** (see Figs. 12, 19, and 25).—The pharynx has as its roof or vault the under surface of the body of the sphenoid and part of the basilar process of the occipital bone; as its posterior wall, the anterior surfaces of the cervical vertebræ from the second to the sixth.

On its anterior wall are the orifices of communication with the nose and mouth (Fig. 26); on its lateral walls, the soft parts over the internal carotid artery, and ninth, tenth, and twelfth nerves, and the orifice of the Eustachian tube.

Its lower limit is formed by the larynx and by the beginning of the esophagus (Fig. 19). It is about five inches in length; the distance from the arch of the teeth to the beginning of the esophagus is about six inches, and a finger introduced into the mouth can touch the second, third, fourth, fifth, and sixth cervical vertebræ. The pharynx is lined throughout by mucous membrane, which is continuous with that of the nose and mouth. Its curved roof or vault and posterior wall are frequently the seat of lymphoid tissue, which enlarges considerably under certain conditions, forming an obstruction to the posterior nares, and requiring removal by a special instrument. The relation of this lymphoid tissue or adenoid vegetation to the orifice of the Eustachian tube on the lateral wall of the pharynx causes it to assume considerable importance in the etiology of deafness (see Figs. 12 and 17). Patients who have such enlarged pharyngeal tonsils can breathe but little through the nose, giving rise to a lack of development of the upper half of the face in children, and an increase in the arching of the vault of the palate. On the lateral wall of that portion of the pharynx known as the nasopharynx, which lies above the soft palate, is seen the orifice for the Eustachian tube (see Fig. 12). On the anterior wall are seen the two posterior nares and the posterior ends of the three turbinated bones. At its lower end (the junction with the esophagus, about opposite the cricoid cartilage) is a favorite place for foreign bodies to lodge (Figs. 12, 19, and 25). On the posterior wall there is a lymph-gland situated in the median line, which frequently breaks down, forming a retropharyngeal abscess in children, which can be felt as a bulging on the posterior wall of the pharynx when the finger is introduced into the mouth. Such a retropharyngeal abscess, as it is called, may be formed as a result of tuberculosis of the cervical vertebræ, and should not be opened through the mouth if possible, but by an incision made along the anterior border of the sternocleidomastoid, opposite the angle of the jaw. The retropharyngeal connective tissue is continuous with that of the posterior

artery, and its veins empty into the facial vein, and by some radicles of the ophthalmic vein into the cavernous sinus. This latter communication between the veins of the exterior and those of the interior of the skull has been referred to above as being of great importance in cases of infection. The nasal lymphatics drain into the submaxillary deep cervical glands.

The **internal nose** serves two purposes. In its uppermost portion (sides of bony septum and over ethmoid bone) it contains the terminal filaments of the olfactory nerve. Its lower portion serves to warm the inspired air as it passes to the lungs. It has, opening into its lateral walls, the lachrymal duct which conveys the tears from the eye (Fig. 12), and also a number of pneumatic cavities, or accessory sinuses, situated in the bones of the face and skull. The exact function of these accessory sinuses is not clear. They, like the mastoid cells, are scarcely developed in infants. In their development they probably aid through giving the facial bones an opportunity to grow without increasing their bulk. If a nasal speculum is inserted into the nostrils (anterior nares), one notes first that for a distance of one-half of an inch the skin of the face lines the external openings of the nose and has many hairs, called "vibrissæ." They serve to arrest dust particles, and at times the sebaceous glands supplying them become inflamed, giving rise to little furuncles which cause considerable swelling and severe pain in the face. One can see upon the lateral walls the anterior ends of the middle and inferior turbinated bones covered by reddish mucous membrane. The **septum** is composed of a cartilaginous, or anterior, and a bony, or posterior, portion (see Fig. 25). The cartilaginous portion is formed by a quadrangular cartilage which assists in supporting the external nose. The bony septum is formed by the perpendicular plate of the ethmoid and the rostrum of the sphenoid above and the vomer below. The septum divides the nose into two lateral halves which are perfectly similar in function and structure.

Deviations of the septum are present in the majority of adults (240 in 370, Zuckerkandl). Most frequent is the bending to the right, affecting almost always the anterior two-thirds of the septum (see Fig. 29). This deviation is probably due to the fact that the septum grows more rapidly than the surrounding bony structures, and is bent either in a circumscribed or a diffuse manner.

On the lateral wall of each half of the nose are three ridges projecting into its lumen, covered with mucous membrane (see Figs. 12, 24, and 29). They are the **turbinated bones,** the two upper (superior and middle) being a part of the ethmoid bone and the lowest (inferior) a

separate bone. The spaces between them are called meati, and have opening into them the lachrymal duct into the inferior; the orifices of the antrum of Highmore, frontal sinus and anterior ethmoidal cells into the middle meatus; and the orifices of the sphenoidal and posterior ethmoidal cells into the superior meatus (see Figs. 12, 25, and 29). The entire internal nose is lined with a mucous membrane which is continuous with that of the pharynx and that lining the accessory cavities. For this reason, inflammation may extend by continuity into either the accessory sinuses or into the pharynx, and from the latter into the middle ear (see Ear) through the Eustachian tube. The orifices of the sinuses are so small and so poorly situated (see Figs. 25 and 29) for drainage that when once infected the mucopurulent secretion can be easily retained.

The orifices may be entirely closed up by the swollen condition of the mucous membrane, and an empyema or collection of pus in a sinus (sinusitis) result. On account of the rigid bony wall, the pain may be quite intense, referred to the supra-orbital region in a case of frontal sinusitis, to the forehead in the median line in ethmoiditis, or over the upper jaw or molar teeth, for empyema of the antrum (Fig. 20).

Cases of frontal sinusitis have been treated for supra-orbital neuralgia, on account of the proximity and accompanying involvement of the nerve. There is frequently a communication between the frontal sinus and anterior ethmoidal cells (see Fig. 25) which may explain the obstinacy of cases of infection of the former. It is exceedingly difficult to open the orifices of these sinuses through the nose, especially the frontal and antrum, and practically impossible in the case of the ethmoidal and sphenoidal sinuses, so that they must generally be opened through their walls, the antrum either through its floor (tooth extraction) or anterior wall, the frontal and ethmoidal by external incisions and chiseling (see Fig. 20) and the sphenoidal through the nose.

The **mucous membrane** covering the free edge and upper surface of the turbinated bones, as well as that of the corresponding portions of the septum, is an erectile tissue which swells to such an extent under certain nervous and infectious conditions that the entire lumen is obstructed. This condition is present in hay-fever, and in acute and chronic rhinitis. The blood-supply of the nose is derived from the internal maxillary (sphenopalatine) artery, which enters it from the posterior half. Nasal hemorrhage (epistaxis) is rarely severe, especially if from the anterior half of the nose, which has the smallest vessels. It usually ceases after tamponing the anterior nares. Occasionally the hemorrhage may be so severe as to require tamponade of the opening of the nose into the pharynx (see Fig. 19).

The **veins** of the upper portion of the nose empty into those of the dura, those of the lower portion into the veins of the pharynx and face. The **lymphatics** empty into a gland in front of the second cervical vertebra and into the deep cervical glands. The first-named relation of the lymphatics may explain the frequency of retropharyngeal abscess in infants, secondary to rhinitis. There is also communication between the lymphatics of the nose and the subarachnoid space. This is the reason why a septic meningitis at times complicates empyema of the upper air-cells (ethmoidal). The anatomic fact that the deep cervical glands drain the lower portion of the nose explains their frequent secondary involvement (tubercular lymphadenitis) when the primary atrium of infection has been in the nose. Syphilis or atrophic rhinitis may give rise to necrosis of either the bony or cartilaginous portion of the septum, causing the roof or external nose to fall in, giving rise to the deformity known as saddle-nose (Fig. 28).

**Fractures** of the external nose usually involve the nasal bones, but frequently there is a separation from their attachments to the frontal and superior maxillæ and to the quadrilateral cartilages. The latter are often bent inward by a trauma. Deviations of the septum at times follow an injury. A fracture of the nose may extend through the ethmoid (which forms the roof of the nose) into the anterior fossa of the skull. The lachrymal duct may be obstructed as the result of a fracture. A fracture involving the frontal sinuses may cause escape of air into the subcutaneous cellular tissue (emphysema).

## The Orbit and Eye.

**The Orbit.**—The orbits or sockets for the eye consist of two pyramidal-shaped cavities, with their apices behind. The axes, if prolonged, would pass through the optic foramina, and meet behind the pituitary fossa of the sphenoid. Each orbit is composed of the frontal, sphenoid, ethmoid, malar, lachrymal, palate, and superior maxillary bones.

The bones forming the roof, floor, and inner wall of the orbit are very thin, and consequently in close connection with the nasal fossa, the ethmoidal, sphenoidal, frontal sinuses, and the antrum of Highmore, so that foreign bodies thrust into the orbit might easily penetrate these structures, or, vice versa, tumors may readily invade the orbit by destroying the thin bony wall intervening between these cavities (Figs. 25 and 29).

The apex or posterior portion of the orbit presents (1) the optic foramen for the transmission of the optic nerve and the ophthalmic artery; (2) the sphenoidal fissure through which passes the ophthalmic

nerve (the first branch of the trigeminus), and the nerves supplying the muscles of the eye; (3) the sphenomaxillary fissure transmitting the second branch of the trigeminus.

At the upper inner angle of the superior border of the orbit is found the supra-orbital notch, for the transmission of the supra-orbital nerve and artery; while below, on the inferior border, the infra-orbital nerve and artery emerge through the infra-orbital foramen (see Fig. 5).

The orbital nerves may be injured in wounds or fractures involving the orbit, or be pressed upon by tumors or bony exostoses from various parts.

The orbit contains the eyeball, with its attached muscles, the optic nerve, lachrymal gland, blood-vessels, nerves, fat, and fasciæ.

The bony wall of the orbit is covered by periosteum. Immediately beneath it, forming a loose delicate sheath for the muscles, is the orbital fascia, containing a large quantity of loose fatty cellular tissue. It is by the absorption of this fat in extreme emaciation and in the aged that recession of the eyeball or enophthalmus is produced. Owing to its loose structure, it affords easy means for the spread of orbital suppuration. In Basedow's disease, or exophthalmic goiter, one of the chief symptoms is the protrusion of the eyeball (exophthalmus).

Surrounding the globe from near the margin of the cornea to the entrance of the optic nerve is Tenon's capsule. This investment consists of a visceral and a parietal layer. The parietal layer clothes the fatty tissue surrounding the globe, and the visceral layer covers the posterior part of the eyeball from the margin of the cornea to the entrance of the optic nerve. As the tendons of the ocular muscles pierce Tenon's capsule, the latter gives off some fibers, which are reflected upon them, thus reinforcing the sheaths of the muscles.

The blood-supply of the orbit is derived from the ophthalmic artery. Traumatism of the orbit may produce pulsating tumors of one of the orbital arteries.

To the eyeball are attached six muscles: the four recti—external, internal, superior, and inferior—and the two oblique—superior and inferior (see Fig. 22). The four recti take their origin about the optic foramen, and are inserted into the sclera by a tendinous expansion, about ten millimeters wide. Their insertion is not equidistant from the sclerocorneal junction, but varies. The internal rectus is about 6.5 millimeters from the limbus corneæ; the external rectus, 7 millimeters; the superior rectus, 8 millimeters; and the inferior rectus, 7.5 millimeters. The tendon of the external or internal rectus muscles is frequently divided in cases of strabismus.

**The Globe.**—The cornea forms the clear, transparent, anterior part of the fibrous coat of the eye. It is slightly elliptic in shape, with the major axis in the horizontal meridian. The cornea is composed of five layers, the greater part of which consists of a large number of bundles of connective-tissue fibers (lamellæ), between which are anastomosing cell-spaces containing the corneal corpuscles. It is along these cell-spaces that suppuration takes place. Except at the limbus the cornea contains no blood-vessels, but it is richly supplied with nerves derived from the ciliary plexus, formed by the long and short ciliary nerves.

**The sclera,** together with the cornea, form the external fibrous coat of the eye. It is thickest at its posterior part, where it measures about one millimeter in thickness. Anteriorly it is pierced by a number of minute openings through which the anterior ciliary arteries and veins pass. Posteriorly it is pierced by the optic nerve.

**The choroid** forms the dark coating of the eye, and is the vascular tissue of the globe supplying nutrition to the vitreous, retina, and lens. In injuries to the globe excessive hemorrhage may take place from this structure.

**The retina** is a thin transparent membrane, placed between the hyaloid membrane of the vitreous within and the choroid externally. Its attachment to the choroid is so delicate that it may be detached by traumatism, hemorrhage, or effusions. The optic nerve pierces the posterior pole of the eye about three millimeters to its inner side, at a spot known as the papilla or disc.

**The aqueous chamber** is bounded anteriorly by the cornea, posteriorly by the capsule and suspensory ligament of the lens. This space is again divided by the iris into the anterior and posterior chambers, collecting the lymph of the anterior portion of the eye, known as the aqueous humor. Any cause tending to interfere with the normal circulation of fluid from the vitreous through to the posterior and anterior chambers produces an increase of intraocular tension of the globe; a condition known as glaucoma.

**The vitreous** is a transparent colorless mass filling the posterior cavity of the globe, depending for its nutrition upon the surrounding structures, which, when diseased, usually affect the vitreous.

**The iris** is the colored membranous diaphragm immediately in front of the lens, containing a central opening, the pupil. It extends from the ciliary body over the lens, while its central or pupillary border lies upon the anterior capsule of the lens. The vessels of the iris and choroid are so closely related that inflammations set up in the iris very easily spread

to the choroid. When the iris is inflamed, its color is altered, due to congestion and exudation into its substance. After iritis, therefore, it is not uncommon to find the posterior surface of the iris adherent to the anterior capsule of the lens (posterior synechiæ).

**The ciliary body** is a circular organ, extending from the base of the iris to the anterior part of the choroid. It consists of the ciliary muscle and processes. Wounds involving this region assume grave characters, owing to the other structures usually affected. If the ciliary body be injured, the sclera, choroid, retina, vitreous, conjunctiva, and iris may all be involved.

**The lens** is a biconvex transparent body, inclosed in a capsule and held in position by its suspensory ligament. It separates the vitreous chamber behind from the aqueous chamber in front. It is composed of a central portion, the nucleus, and a softer peripheral portion, known as the cortex. In the various forms of cataract, the whole lens or some portion of it or of its capsule becomes the seat of the opacity.

**The conjunctiva** is a delicate thin mucous membrane covering the posterior surface of the eyelids, and is reflected on to the anterior surface of the globe, forming the conjunctival sac. It is divided into the palpebral, that covering the posterior portion of the lid; the ocular or bulbar, covering the anterior part of the globe; and the fornix or transition fold, that portion between the lid and globe. The part of the palpebral portion that covers the tarsus is known as the tarsal conjunctiva.

**The eyelids** are two movable folds of skin, covering the eyeball, which by their attachments close in the orbital cavity. The outer margins of the lids unite to form the external canthus. At the inner margin, the internal canthus, a small red elevation is found, known as the caruncle (see Fig. 20). The following layers are found from before backward: The skin, loose connective tissue, muscular tissue, tarsal cartilage and fascia, and conjunctiva. The lids owe their stiffness to the tarsal cartilages. The margins of the lids are fringed with short hairs or cilia. On everting the lid, the openings of the Meibomian glands are seen.

**The lachrymal apparatus** consists of the lachrymal gland or secretory portion and the lachrymal passages.

The lachrymal gland is divided into two parts, the larger of which is situated in the upper external angle of the orbit, while the smaller is placed just beneath the mucous membrane of the fornix.

The remainder consists of the puncta lachrymalia, the canaliculi, the sac and nasal duct (see Fig. 20). The puncta are seen as minute openings at the inner extremity of each lid about six millimeters from

the internal canthus. The canaliculi are the continuations of the puncta, extending vertically for a short distance, and then continuing horizontally, emptying into the lachrymal sac. The lachrymal sac is situated in a groove at the inner angle of the orbit, and empties in the nasal duct (see Fig. 20). The nasal duct passes downward and slightly outward and backward, varying in length from twelve to twenty-two millimeters, and in its diameter from three to six millimeters. It terminates just below the inferior turbinate body.

# THE NECK.

**Examination of the Neck during Life.**—Where the face passes into the neck, the horseshoe-shaped border of the lower jaw can be felt as the upper boundary of the neck. The lower boundary is formed by the upper border of the sternum, by the clavicle and a line drawn from the acromioclavicular joint to the seventh cervical spinous process. Beginning from above, one should palpate the following points:

1. The lower border of the lower jaw.

2. Following downward in the median line, the hyoid bone, of which one can feel the body and greater cornu.

3. The thyroid cartilage, the upper border of which corresponds to the point of division of the common carotid artery into the internal and external carotids.

4. The cricoid cartilage immediately below the thyroid. When the head is drawn backward, one can feel between these two cartilages the tense cricothyroid membrane.

5. From the cricoid cartilage downward to the upper border of the sternum, the upper five or six tracheal rings can be felt just beneath the skin, especially when the head is thrown backward.

6. External to the median line, on both sides, palpate the sternocleidomastoid muscle from its point of origin at the mastoid process to its insertion at the sternoclavicular joint. There is occasionally a space between its sternal and clavicular attachments.

7. Along the anterior border of this muscle can be felt the pulsations of the common carotid artery, and if the fingers are pushed in still deeper, the transverse processes of the third to seventh cervical vertebræ can be felt. The transverse process of the sixth is quite prominent, and is frequently called the carotid tubercle, being a favorite point of ligation of the common carotid artery.

8. When the head is turned to one side, note the external jugular vein extending from the middle of the clavicle to the angle of the jaw. This can be made more prominent by compressing it at its lower end. In some individuals there is, under normal conditions, a venous pulse visible in this vein.

9. Palpate the trapezius muscle, extending from the superior curved line of the occipital bone to the spine of the scapula and clavicle. It can be made especially prominent when the head is drawn to one side.

10. Under these conditions palpate the space between the posterior border of the sternocleidomastoid muscle and the anterior border of

the trapezius. This is the posterior triangle of the neck. At its lower portion can be distinctly felt the pulsations of the subclavian artery, and a little higher up, a number of firm cords passing obliquely from the spine toward the arm—the brachial plexus.

**Surface Markings of Neck** (see Figs. 30 and 31).

Mark the following structures:

1. External jugular vein from middle of clavicle to angle of jaw.

2. Common carotid artery from sternoclavicular joint, along anterior border of sternocleidomastoid muscle to upper border of thyroid cartilage.

3. External and internal carotid arteries from upper border of thyroid cartilage along anterior border of sternocleidomastoid muscle to a point midway between angle of jaw and mastoid process.

4. Internal jugular vein and vagus nerve—line drawn along middle of sternocleidomastoid muscle parallel to and external to the common carotid artery, the vagus nerve lying between the vein and the artery, but at a deeper level.

5. Superior thyroid artery—line drawn from the angle of junction of the sternocleidomastoid muscle and hyoid bone obliquely downward and inward toward the median line.

6. Lingual artery above the superior thyroid—line drawn from the above-mentioned angle of junction of the hyoid bone and sternocleidomastoid muscle at first parallel to the hyoid bone, then obliquely upward and inward toward the lower jaw.

7. Facial artery—line from above angle in a tortuous manner to anterior border of masseter muscle and lower border of lower jaw.

8. Occipital artery—line from point of origin of facial artery to point midway between mastoid and occipital protuberance.

9. Subclavian artery and vein correspond to a curve with convexity upward, drawn from sternoclavicular joint to middle of lower border of clavicle, the summit being one and a half inches above the latter; the third portion of subclavian corresponds to posterior border of sternocleidomastoid muscle. The subclavian vein lies immediately in front of, and below, the artery.

10. Phrenic nerve—line parallel to middle of sternocleidomastoid muscle from hyoid bone downward.

11. Spinal accessory nerve—emerges opposite middle of posterior border of sternocleidomastoid muscle, passing obliquely across posterior triangle to anterior border of trapezius muscle at level of seventh cervical vertebra.

12. The superficial cervical nerves all emerge close to the middle of

the posterior border of sternocleidomastoid muscle; the great auricular and small occipital passing upward and backward to the skull, the superficial cervical winding around the muscle toward the median line in front, and the three descending branches, supraclavicular, suprasternal, and supra-acromial, directly downward and outward.

13. Sympathetic nerve—line following closely that of common carotid artery, its superior cervical ganglion being opposite the second or third cervical vertebra.

14. Brachial plexus, corresponds to a line drawn from a point opposite the cricoid cartilage—that is, about middle of sternocleidomastoid muscle—to one a little external to the middle of the clavicle.

For practical purposes we may divide the neck into three regions:

1. Anterior—bounded above by the lower jaw.
   below by the sternum.
   laterally by the sternomastoid muscles.
2. Lateral—bounded anteriorly by the sternomastoid muscles.
   posteriorly by the trapezius.
   below by the clavicle.
3. Posterior—embracing the remainder.

The **anterior region** may be subdivided on each side of the median line into a (1) submaxillary region, or triangle; (2) carotid region, or triangle (see Figs. 30 and 31).

The skin of the anterior region is fine, very elastic, and readily adapts itself for plastic operations. It is freely movable everywhere upon the underlying structures. It contains, especially under the jaw, many sebaceous glands, which are a frequent seat of acne and also develop into sebaceous cysts. The latter are, like those of the scalp, very superficially situated. The skin over them is stretched and, unless inflamed, freely movable. The subcutaneous tissue, especially in the obese, contains much fat, giving rise at times to a prominence below the chin (double-chin). Not infrequently lipomata will form in this layer, sometimes quite circumscribed, but often quite diffuse and more or less symmetrically situated (symmetrical lipomatosis). The small veins and lymphatics of this layer may be the seat of congenital cystic tumors (hemangioma and lymphangioma), which may attain an enormous size, penetrating the fascia and passing around the deeper structures in all directions (see Fig. 32).

Following scarlatina, a severe phlegmonous inflammation of this connective tissue occurs (angina ludovici), beginning at the floor of the mouth and spreading rapidly downward, giving rise to a tense, brawny infiltration of the skin and underlying fibrous tissue. Imme-

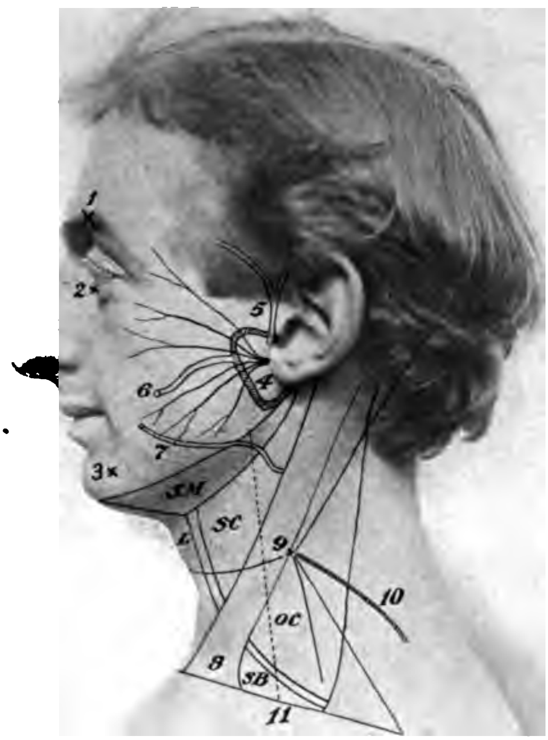


Fig. 30.—Surface markings of superficial structures of side of face and neck. 1, 2, and 3, Points of emergence of supra-orbital, infra-orbital, and mental nerves respectively. 4, Parotid gland. Just above the figure the facial nerve is seen dividing inside of the gland into six principal branches. 5, Superficial temporal artery dividing into its anterior and posterior branches. 6, Steno's duct opening opposite second upper molar tooth. 7, Facial artery. 8, Sternocleidomastoid muscle. 9, Points of emergence of superficial cervical and spinal accessory (in heavy outline) nerves opposite middle of posterior border of sternocleidomastoid. 10, Trapezius muscle. 11, Surface marking of external jugular vein from middle of clavicle to angle of jaw. SM, Submaxillary triangle. SC, Superior carotid triangle. L, Inferior carotid triangle. OC, Occipital triangle. SB, Subclavian triangle.


Fig. 31.—Surface markings of deeper structures of face and neck. V, Fifth nerve with its three principal branches emerging from Gasserian ganglion. 1, Placed upon condyle of lower jaw, the thick black line above it representing the temporomaxillary joint. 2, Internal maxillary artery, the branch passing upward representing the middle meningeal. 3, Posterior auricular artery. 4, Occipital artery. 5, Facial artery. 6, Lingual artery. 7, Superior thyroid artery; immediately below its lower end, the inferior thyroid branch of the subclavian is seen. 8, Placed just above the bifurcation of the common carotid into the internal and external carotid. 9, Internal jugular vein. Heavy black line between 8 and 9 represents the vagus nerve lying between the common carotid artery and internal jugular vein, but at a deeper level. 10, Spinal accessory nerve as it passes across the posterior triangle of the neck. 11, Upper border of apex of lung. Note its relation to 12, the brachial plexus. 13, The subclavian artery. 14, The thoracic duct.

Fig. 32.—Congenital tumor, child's neck (cavernous hemiangioma).


Fig. 33.—Cross-section of neck at level of larynx, showing arrangement of deep cervical fascia, etc. 1, External jugular vein. 2, Sternocleidomastoid muscle. 3, Internal jugular vein. To its inner side is seen the common carotid artery, and lying between the two, but at a posterior level, the vagus nerve on each side (white dot). 4, Placed in larynx between true vocal cords. 5, Placed between cricoid and thyroid cartilages. 6, Sternohyoid muscle. 7, Thyroid gland. 8, Body of cervical vertebra, above which the spinal cord and ligamenta denticulata are seen. 9, Brachial plexus. 10, Trapezius muscle. 11, Muscles at back of neck. The line points to the middle (previsceral) layer of the deep cervical fascia, and can be followed forward. 12, Vertebral vessels and sympathetic nerve. The dotted line represents the prevertebral layer of the deep cervical fascia. Between the cricoid cartilage (5) and the body of the vertebra (8), but separated from it by the prevertebral fascia, is seen the esophagus.

Fig. 34.—Front view of branchial cyst.

diately beneath the cellular tissue is the superficial or outer layer of the deep fascia, which forms a firm investment for the organs of the neck. Its upper limit extends from the occiput to the chin; its lower is attached to the sternum, clavicle, acromion, and spine of the scapula (see Figs. 33 and 35). It is attached behind to the ligamentum nuchæ and is continuous across the median line in front. It divides to include the sternomastoid and trapezius muscles (see Figs. 33 and 35). Opposite the hyoid it divides to inclose the submaxillary gland, and is then attached to the jaw (Fig. 35). For these reasons abscesses of the submaxillary gland are under great tension and often take a deeper course. Abscesses situated elsewhere tends to gravitate toward the lower attachment of the fascia, or, if from the spine, are limited by the sternomastoid and trapezius muscles, often lying within their fascial sheath. Along the anterior border of the sternomastoid there are frequently situated the openings of certain **congenital fistulæ,** known as branchial. They are the remnants of clefts lined by flat-cell epithelium which lie between the branchial arches in early embryonic life and permit of communication between the surface and the pharynx. These may close imperfectly, remaining open at either end. If the external openings remain, they are usually at the sternoclavicular joint (last cleft, see Fig. 37) or opposite the larynx. If the opening of the incomplete canal is external, it is usually situated at the beginning of the esophagus, or at the posterior pillar of the fauces, near the tonsils. They admit a fine probe. **Branchial cysts** arise from the retention of secretion in such a canal. They usually appear in adolescence. If placed near the cutaneous end, the secretion is sebaceous (deep atheroma); if near the pharynx, glairy mucus. The most common situation of these cysts is in the third cleft between the thyroid gland and sternomastoid muscle. An epithelioma may develop from the squamous epithelium lining the cleft, characterized by a deep-seated tumor beneath the sternomastoid, indefinite in outline and of firm consistence (branchiogenic carcinoma). Another embryonic structure may occasionally persist, the thyroglossal duct, and open at the upper border of the thyroid cartilage (see Fig. 37).

**Submaxillary Region, or Triangle** (see Figs. 30 and 38).

Upper boundary—Lower jaw and line continued to mastoid process forms base of triangle.

Lower boundary—in front { from anterior portion of hyoid bone to chin corresponds to anterior belly of digastric.

Lower boundary—behind { *i. e.*, from mastoid to anterior portion of hyoid bone, corresponds to posterior belly of digastric.

The superficial layer contains (beneath the superficial layer of the deep fascia) the anterior facial vein, which crosses the region from the lower jaw to empty into the anterior jugular (see Fig. 38). It may become thrombosed in cellulitis of the neck and the thrombophlebitis may spread upward along the internal jugular vein and cause meningitis. The facial vein accompanies the facial artery, which is far more tortuous, dipping in at times to the floor of the mouth, so close to the tonsil that it may occasionally be cut tangentially by a tonsillotome. Almost the entire superficial layer is occupied by the **submaxillary salivary and lymph-glands,** inclosed between the two layers of deep cervical fascia above described (see Fig. 33). The lymph-glands are often imbedded within the submaxillary salivary gland. They drain the cheek, gums of lower jaw, and lateral portion of lips and tongue (see Fig. 39). Hence they are enlarged in infectious or malignant processes involving these parts; *e. g.*, carious teeth or carcinoma of lips and of tongue. In infectious processes, especially in children, they readily form an abscess. In malignant or tubercular disease their removal may necessitate extirpation of the submaxillary salivary gland. The latter is frequently the seat of an epidemic inflammation, like the parotid. (Submaxillary "mumps.")

In the same layer near the median line, beneath the chin and between the two anterior bellies of the digastric muscles, are several glands (submental) which drain the median portion of the lower lip and must be examined in cases of carcinoma of the lower lip.

The submaxillary gland is separated by a layer of fascia from the deep layer of this region (see Fig. 38). Immediately beneath it are the styloglossus and hyoglossus muscles externally, and the mylohyoid to the median side. The two latter muscles unite (mylohyoid of each side) in the median line to form the floor of the mouth. The hypoglossal nerve lies upon the hyoglossus muscle accompanied by the lingual vein, crossing it obliquely to dip under the external border of the mylohyoid and then pass upward to the tongue. Immediately above it is Wharton's duct, which also crosses the hyoglossus muscle and the lingual nerve, lying close to the inner margin of the lower jaw until near the median line, where it passes upward into the mouth. Unless care is taken in the removal of the submaxillary glands, the hypoglossal nerve may be injured, being separated only by a layer of fascia. The lingual artery passes across the greater cornu with the hypoglossal nerve, but instead of passing obliquely upward and inward like the nerve, it lies parallel at first with the hyoid (beneath the hyoglossus muscle), then passes vertically upward to the tongue. It is often ligated prelim-

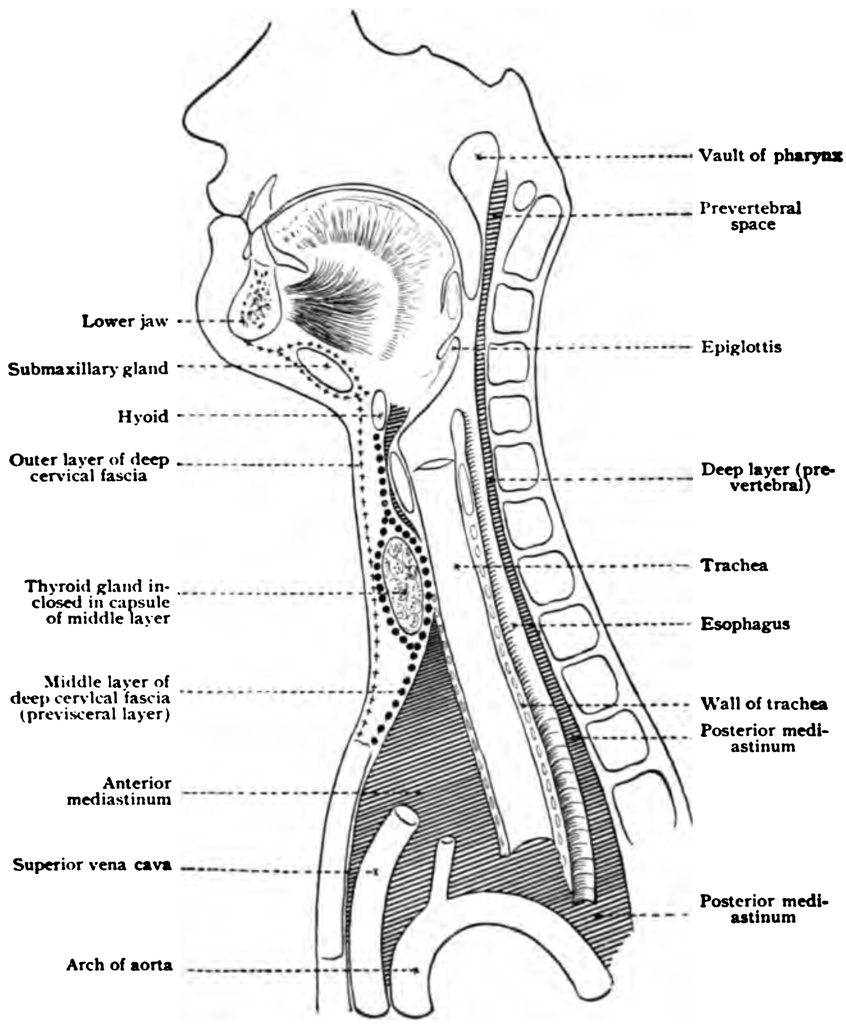


Fig. 35.—Vertical view of deep cervical fascia (diagrammatic), showing how suppuration may extend by continuity from the head and neck to the anterior and posterior mediastinum.

Fig. 36.—Method of examination in order to determine enlargement of the submaxillary or submental glands. The examiner should stand in front of the patient, or both may be seated in the same relation to each other. The patient should be instructed to relax the muscles which pass from the lower jaw to the hyoid bone by flexing the head upon the neck, when the finger tip of the examining hand may be inserted for a considerable distance further than if the head were extended.


Fig. 37.—Surface markings of principal structures of neck, and of thorax in child. 1, Upper border of thyroid cartilage. 2, Cricoid. 3, Rings of trachea above isthmus of thyroid. 3′, Rings of trachea below isthmus of thyroid. 4, Isthmus of thyroid. 5, Common carotid artery. 6, Anterior border of the sternocleidomastoid. 7, Subclavian artery. 8, Innominate artery. 9, Right innominate vein. 9′, Left innominate vein. 10, Superior vena cava. 11, Line of absolute cardiac dullness, according to Sahli. 12, Area of absolute cardiac dullness. 13, Right auricle. 14, Left auricle. 15, Right ventricle. 16, Left ventricle. 17, Lower border of pleura. 18, Pulmonary artery. A, Aorta. Th, Thymus gland. M (in neck), Most frequent opening of thyroglossal duct. L, Most frequent openings of branchial fistulæ. M (in thorax), Mammary line. P, Parasternal line.

inary to removal of the tongue and can be found by pulling the submaxillary gland upward when the hypoglossal nerve is exposed. The hyoglossus muscle which lies beneath the nerve is then divided transversely and the artery is readily found. To the outer side of the artery is the glossopharyngeal nerve at a still deeper level, accompanied by the styloglossus and stylopharyngeus muscles. The latter lies directly upon the superior constrictor of the pharynx, being separated from it only by mucous membrane (Fig. 19). Close to the inner side of the lower jaw is the lingual nerve and Wharton's duct (Figs. 12 and 38) on either side of the neck.

The **carotid triangle** has as its

1. Upper boundary—the posterior belly of digastric continued to the median line.
2. Externally—Sternocleidomastoid muscle.
3. Internally—Median line.

The anterior belly of the omohyoid muscle divides it into a superior and an inferior carotid triangle; *i. e.*, all above a line crossing the sterno-mastoid, opposite the cricoid and prolonged to the hyoid, forms the superior; all below, the inferior (Figs. 30 and 38) carotid triangle. For clinical purposes, we shall speak of them as one.

Immediately beneath the fascia (outer layer of deep) (see Fig. 30) are the **anterior jugular veins,** which send many branches across the median line (see Figs. 37 and 38). In cases of diphtheria or any other form of laryngeal or tracheal stenosis they become engorged and may give rise to considerable hemorrhage during tracheotomy. Immediately beneath are the sternohyoid and the sternothyroid muscles. The former is nearer the median line; they are of value as guides to the trachea lying beneath them (see Fig. 41). A little more externally is the **carotid sheath,** lying beneath the sternocleidomastoid muscle close to its anterior border. Opposite the cricoid the sheath is crossed obliquely by the omohyoid muscle lying beneath the sternocleido-mastoid (see Fig. 38). The **sternocleidomastoid,** as stated above, is enclosed in a sheath of the outer layer of the deep cervical fascia. It is supplied by the spinal accessory nerve, which enters it opposite the hyoid and emerges from it at the middle of the posterior border (Figs. 30 and 38). This muscle is at times injured during birth, and the resulting hematoma and cicatrix may be mistaken for a tumor. In congenital wryneck due to rigid contraction of the muscle, the chin is turned toward the sound side and the head is brought down toward the affected side. The muscle may contract spasmodically (either directly or reflexly), necessitating operation on the spinal accessory supply-

ing it. Tenotomy of this muscle is best performed by the open method.

On its anterior surface (external to the fascia enclosing it) the muscle is crossed (opposite its middle) by the external jugular vein (see Figs. 30 and 38). On its posterior surface the muscle is in relation with the superficial branches of the cervical plexus which emerge from the posterior border at about its middle, with the brachial plexus, the carotid sheath (Figs. 31 and 33), and below with the subclavian vessels (Figs. 38, 41, and 42). Along both of its borders and beneath it are many lymph-nodes (deep cervical), so that the muscle must be pulled forward or backward in their removal. At times a temporary resection of the muscle has been made to facilitate their removal. These nodes receive their lymph from the interior of the skull, temporal and sphenomaxillary fossæ, orbits, tongue, larynx, nose, upper jaw, palate, pharynx, and thyroid (see Fig. 39). This causes marked enlargement when the infection atria have been in the mouth, nose, or pharynx (diseased tonsils, adenoids, carious teeth, middle-ear disease, etc.). They form firm adhesions to the carotid sheath, especially to the internal jugular vein, their removal often resulting in injury to the important structures contained in the sheath or to the spinal accessory nerve before or after its passage through the sternomastoid muscle.

In the **carotid sheath,** formed by the deep layer of the cervical fascia, lie the common carotid artery close to the anterior border of the sternomastoid, the internal jugular vein on the outer side, and, at a deeper level between these, the vagus (see Figs. 30, 31, 33, 37, 38, and 41). Inclosed in this sheath are also a number of the deep cervical lymph-glands. The **internal jugular** is more closely attached to the sternomastoid muscle than the carotid is. Opposite the upper border of the thyroid cartilage, the point of division of the common carotid, the internal carotid continues to the base of the skull, lying close to the vertebræ, while the external remains more superficial (Figs. 30 and 38). Just below the lower jaw the internal jugular is crossed by the hypoglossal. Further down, both this vein and the common carotid are crossed by the descendens hypoglossi. In children the upper half of the carotid sheath is entirely exposed on account of the small sternocleidomastoid (see Fig. 37). The sympathetic and its ganglia lie immediately behind the carotid sheath, especially behind the artery. The sympathetic nerve rests upon the muscles in front of the spine (Fig. 33). The superior ganglion lies at the level of the second or third vertebra and is resected for exophthalmic goiter (Jonnesco).

Immediately beneath the sternohyoid and sternothyroid in the

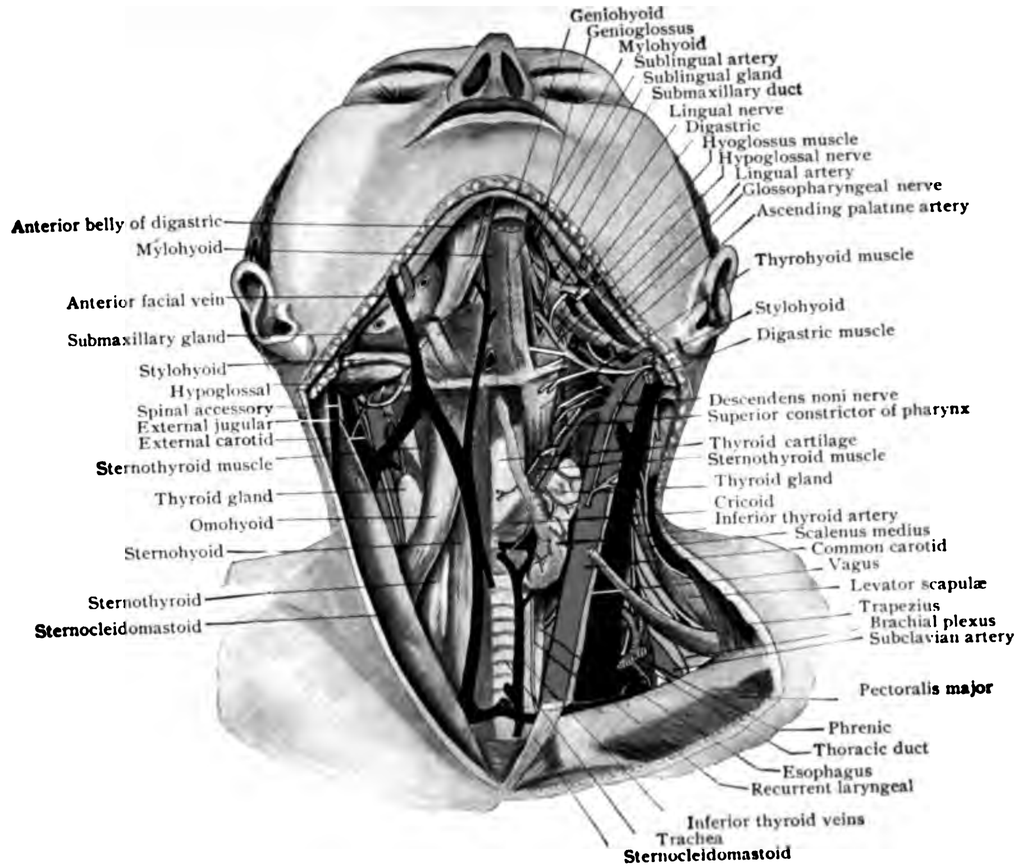


**Fig. 38.—Dissection of superficial (on right side) and of deep layers (left side) of neck (modified after Bardeleben). Veins are black, arteries red, and nerves yellow.**

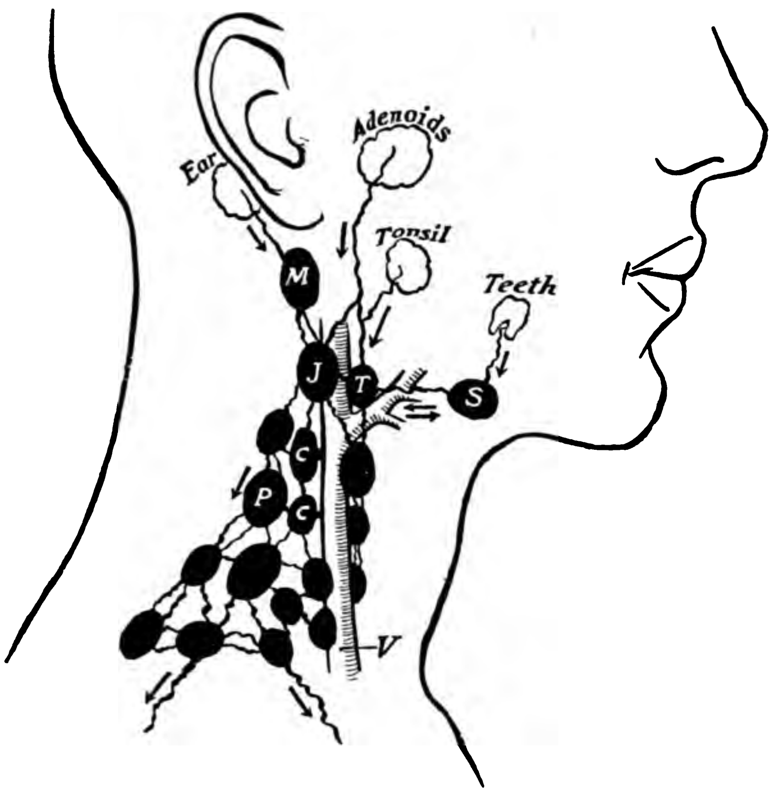


Fig. 39.—Portals of infection and the most frequent nodes involved in tuberculosis of the cervical lymph-nodes. The arrows show the direction of the efferent lymph-vessels leading from the various portals of infection toward the respective nodes which are first infected. *M*, Uppermost node of internal jugular vein which receives the infective material from the ear. *T*, Tonsillar gland located in angle of internal jugular and anterior jugular. This receives the lymph from the tonsil. From *J* downward are to be seen the principal lymph-nodes of the neck which receive the lymph from the head and face. These are the internal jugular group lying beneath the sternocleidomastoid muscle in close relation to the internal jugular vein (*V*) and in direct connection with the lymph-nodes of the posterior triangle of the neck (*P*). *S*, Submaxillary nodes. These lie either upon or within the capsule of the submaxillary salivary gland and receive the infective material from the teeth and jaws, but may be infected by retrograde currents from the tonsillar lymph-nodes. *C*, Two nodes are shown with their short venous branch leading into the internal jugular.

median line lie, from above downward, the hyoid bone and the firm membrane connecting it with the thyroid; then the thyroid containing the larynx, and below it the cricothyroid membrane crossed by the cricoid artery, and, below this, the cricoid cartilage.

**The trachea** is found in the median line. Generally only the first ring can be seen of the trachea; the second is covered by the isthmus of the thyroid gland, and the remainder by fat in the adult as the trachea recedes from the sternum, or by the thymus in children, even when there is no enlargement of the thyroid (see Figs. 33, 37, 38, and 42). The trachea is crossed by the inferior thyroid veins (see Fig. 38).

The hyoid bone lies immediately below and supports the base of the tongue and the epiglottis (Fig. 25). Its body and greater cornua give attachment to the principal extrinsic muscles of the tongue and to the depressors of the lower jaw. Injury to the hyoid may result in a fracture (in hanging, or blows). Below it is the thyrohyoid membrane. This is at times divided in order to gain access to foreign bodies at the orifice of the larynx (low lateral pharyngotomy). It is opposite the epiglottis, and after it has been divided the entire upper opening of the larynx is exposed, as well as the lower parts of the pharynx. The operation must be preceded by a tracheotomy.

Below the cricothyroid, in the median line, are the thyroid and cricoid cartilages containing the larynx. The thyroid cartilage is ossified after the age of fifty, and may be fractured by blows, by strangulation, or by gunshot wounds. **The larynx** is best seen from the oropharynx, by laryngoscopic examination (see Figs. 33 and 15. In front, at the base of the tongue, is the epiglottis. Running backward on each side are two folds of mucous membrane (aryteno-epiglottic) passing to two prominences behind, the arytenoid cartilages. The space between these is the superior aperture of the larynx. Between it and the lateral walls of the pharynx there is a pocket on each side, sinus pyriformis, which is at times the starting-point of an epithelioma, and a frequent location of small foreign bodies. Looking down through the superior aperture, the false vocal cords can be seen at about the level of the middle of the thyroid cartilage. Immediately below them is the rima, or chink of the glottis, or space between the true vocal cords (Fig. 33). The mucous membrane and muscles of the larynx are supplied by the superior and inferior laryngeal nerves; the superior supplies the mucosa down to the vocal cords and also the cricothyroid muscle (renders cords tense); the inferior supplies the remainder of the mucosa and the other muscles of the larynx. Hence, when the superior laryngeal terminal filaments are irritated, we have reflex spasm of the glottis; if paralyzed,

foreign bodies can enter the larynx owing to the insensibility of the epiglottis. When the trunk is pressed on, there results a dry, brassy cough (loss of tension of the cords). When the recurrent laryngeal nerves are irritated, spasm of the muscles of larynx follows; if paralyzed, cadaver position of cords, one or both sides. Such a condition may happen after diphtheria or bulbar paralysis. In aneurisms of the arch of the aorta or of the subclavian or innominate arteries, or in mediastinal tumors or cancer of the upper part of the esophagus, it may also occur, because the left recurrent laryngeal (see Figs. 43 and 69) winds around the arch of the aorta, the right passing around the subclavian artery.

The submucous tissue of the aryteno-epiglottidean folds, and that of the interior of the larynx down to the true cords, is quite easily distended by fluid (serum). In acute inflammatory conditions its swelling causes a narrowing of the superior aperture of the larynx (laryngeal stenosis or edema of glottis). This takes place more readily in children (catarrhal croup) on account of the relatively small size of the larynx. For the relief of edema of the glottis, as well as for the stenosis due to a false membrane occluding the aperture, **intubation** is practised with excellent results. The main anatomic points to be remembered in this operation are:

1. The finger (index), after having been passed well back into the pharynx and brought forward in the median line, encounters a hard nodule, the cricoid cartilage (see Fig. 25).

2. At the same level is the opening of the larynx and the epiglottis.

3. If the tube is not kept in the median line, and in front of the above nodule, it is passed either into the esophagus or into one of the ventricles of the larynx between the true and false vocal cords.

Behind the thyroid and cricoid are the pharynx and esophagus, being separated only by a thin layer of muscle. Externally, both cricoid and thyroid are covered by the thyroid gland (see Figs. 33, 37, 38, 41, 42, and 43). Between these cartilages and the esophagus laterally, and in immediate contact with both, are the recurrent laryngeal nerves, and a little more externally, the carotid sheath (see Figs. 43 and 69). **Laryngectomy** is performed for malignant tumors of the larynx. The principal anatomic relations to be remembered are (see Figs. 38 and 69):

1. The larynx can be best reached by an incision made from the hyoid to the third tracheal ring in the median line.

2. Principal blood-vessels are superior laryngeal artery (upper border of thyroid); cricothyroid artery, between cricoid and thyroid cartilages; inferior laryngeal, upper border of cricoid. These all lie

between the sternohyoid and thyroid muscles and the cartilages (Fig. 38).

3. Nerves. Superior laryngeal, level of upper border of thyroid, immediately below the same artery. Inferior or recurrent laryngeal in the groove between esophagus and larynx as far up as cricothyroid membrane (Figs. 41 and 43).

4. Esophagus and pharynx, latter from upper border of cricoid up; former from that point down, are separated only by thin layer of muscle (Fig. 41).

5. External carotid and superior thyroid arteries lie just external to the thyroid and cricoid cartilages (see Figs. 30 and 38).

Below the cricoid, and firmly connected with it, is the **trachea.**

Under normal conditions the first ring is usually free; the second and third covered by the isthmus of the thyroid (Figs. 37 and 42). The upper rings are quite superficially situated, but as the trachea passes downward, it recedes from the surface, so that the various structures of the lower portion of the neck itself, intervene between it and the skin, in addition to the muscles, fat in adults, and the upper end of the thymus gland in children (Fig. 35). The inferior thyroid veins pass across it at its lower portion, and from these, the large median thyroid (thyroidea ima) vein occasionally passes along the middle of the front of trachea (Fig. 38).

The operation of **tracheotomy** is performed for the purpose of relieving laryngeal stenosis, after unsuccessful intubation, or when the latter is impossible, or as a preliminary operation to removal of the tongue, etc. It is performed either above or below the isthmus of the thyroid gland (second and third rings of trachea). The former (high) operation is preferable, because the trachea is more superficial here. The isthmus of the thyroid is very vascular; hence, it should be pulled downward to avoid injury to it. The incision is made through the skin and intermuscular septum, between the sternohyoid and thyroid muscles (which latter are pulled back) to the extent of about one and a half to two inches from the cricoid downward in the median line. The trachea is fixed on each side by a tenaculum, especially in children, in whom it is very movable, and deeper than in adults. The first and second rings of the trachea are incised in the median line and the cannula inserted. On account of the proximity to the large blood-vessels on either side of the trachea and on account of the esophagus behind, any deviation from the median line will injure the former; and too deep an incision may go through both anterior and posterior walls of the trachea into the underlying esophagus.

On either side of the trachea are the lateral lobes of the **thyroid gland.** The gland is firmly attached to the trachea, being inclosed in a reflection of the deep cervical fascia which forms a capsule for the gland (Figs. 35 and 41). On account of its firm attachment to the trachea, enlargements of the thyroid gland move upward during the act of swallowing. The gland is frequently enlarged, and, if so, the tumor pushes its way on either side between the carotid sheath and the esophagus. It displaces the structures of the carotid sheath and the sternocleidomastoid muscle outward. It may press upon the recurrent laryngeal nerves which lie (Figs. 41, 43, and 69) between the esophagus and trachea, causing either hoarseness or complete paralysis of the vocal cords, or may press upon the sympathetic nerve, causing dilatation of the pupil of the same side. On account of its practically surrounding the trachea, a tumor of the thyroid gland, especially if of long standing, can compress the lateral aspects of the trachea, causing the formation of the deformity known as sabre-sheath trachea. Such a tumor may not only grow backward, compressing the above structures and esophagus, but grow toward the skin, causing a marked prominence at the lower portion of the neck.

In any operation upon this gland, the following points are to be remembered: (1) The chief arterial supply is derived from the superior and inferior thyroid arteries. The superior enters the gland opposite the middle of the thyroid cartilage; the inferior, arising from the thyroid axis of the subclavian, enters it opposite the cricoid (see Figs. 31 and 38). (2) The inferior thyroid artery is accompanied in the upper part of its course by the recurrent laryngeal nerve. (3) The superior thyroid vein often accompanies the artery; the inferior thyroid vein enters the gland on either side of the median line at the same level as the artery, but internal to it. The gland is always inclosed in a capsule attached to the trachea.

Behind the trachea and larynx, in the median line, lies the **esophagus** (see Figs. 33, 35, 41, 43, and 69). It is separated from the anterior surface of the vertebræ (from its beginning at the sixth cervical, opposite the cricoid cartilage) by a space known as the prevertebral, continuous above with the retropharyngeal, but narrower than the latter (Fig. 35). This space is formed by the deep cervical fascia (see below). The esophagus is separated only by muscle, one centimeter thick, from the trachea. Between these, laterally, the recurrent laryngeal nerve lies as far up as the cricothyroid membrane (see Figs. 33, 38, 41, and 43). Externally lie at a deep level the vagus and sympathetic, and, more superficially, the carotid artery and internal jugular vein. Behind the trachea the

Fig. 40.—Anterior view of an enormous cystic goitre, which occupied all of the space between the sternocleidomastoid muscles on either side, and the lower jaw above, and sternum below. It contained a brownish gelatinous fluid with cholesterin crystals.


Fig. 41.—Cross-section of neck at level of apices of lungs 1, Trachea. 2, Esophagus. The white dots between it and the trachea represent the recurrent laryngeal nerves. The lower level of the section is seen in the illustration, that is, one is looking upward at all of the structures indicated. 3, Thyroid gland. 4, Apices of the pleural cavity. 5, Subclavian artery, curving over apex, indicated by white shadow. 6, Internal jugular vein. 7, Common carotid artery. 8, Subclavian vein. Nos. 5 and 8 are seen twice in illustration, owing to the reason that the ascending and descending limbs of the arch of the subclavian vein and artery have been cut. 9, Brachial plexus. 10, Scapula. 11, Humerus. Between 10 and 11 the formation of the shoulder-joint can be seen. Note the relatively large size of the head of the humerus, as compared with that of the glenoid cavity. 12, Long head of biceps, in bicipital groove. 13, Deltoid muscle. 14, Body of vertebra. 15, Subdeltoid bursa. The white dots seen on either side of the vertebra represent the sympathetic nerves. Those to the inner side of 6 upon the right side of the illustration (left side of body) and behind 6 on the left side of illustration represent the phrenic and vagus nerves.

esophagus gradually lies to the left of median line, until at the beginning of the thorax it lies quite to the left of the median line (Fig. 69). Hence, to open the esophagus for the removal of foreign bodies or malignant growths, the incision should be on the left side of the neck. **In passing a stomach-tube** for the first time, the finger should hold down the base of the tongue, and the tube be passed toward the posterior wall of the pharynx, a little more toward the left than to the right. Owing to the close relations between the esophagus, the large vessels of the neck and thorax, and prevertebral space, no force should be used, on account of the danger of perforation into these, causing rupture of a possible aneurism, or the formation of an abscess passing downward to the posterior mediastinum (Fig. 35). Foreign bodies at the beginning of the esophagus can be removed by low lateral pharyngotomy, if it is impossible to extract them through the mouth by various instruments used for that purpose. Esophageal bougies are passed in the same manner as a stomach-tube, the first resistance being opposite the cricoid cartilage (beginning of esophagus), which to those unaccustomed to passing it, gives the impression of a stenosis.

The esophagus (**esophagotomy**) is reached through an incision three inches long, along the anterior border of the left sternomastoid from the level of the cricoid downward. The principal anatomic points to be remembered are (see Fig. 38):

1. The external jugular vein crosses at the upper end of incision.

2. The carotid sheath, crossed by the descendens hypoglossi, lies to the outer side, and must be pushed and held outward.

3. The left lobe of the thyroid gland lies over the lateral aspect of the esophagus and trachea, and must be retracted toward median line.

4. The recurrent laryngeal nerve lies deeply in groove between esophagus and trachea (see Figs. 41 and 43).

## Relations at Lower Part of Neck.

**Beginning in the Median Line.**—The trachea lies in the median line; behind it lies the esophagus (a little to the left of it). In front are the inferior thyroid veins, the left innominate vein (behind upper border of sternum), and the innominate artery. Between the trachea and common carotid arteries are the recurrent laryngeal nerves on either side. Externally, from within outward, behind the sternoclavicular joint, lie, on the right side, the innominate artery and vein; on the left side, the common carotid and subclavian arteries and innominate vein. Above this joint, on both sides from within outward, the relations are almost the same; namely, the common carotid artery, external to which is the internal

jugular vein and vagus nerve, the latter crossing the subclavian artery in its first portion. At the same level, still more externally, lie the subclavian veins, in front of the arteries (Figs. 41 and 43). On the left side the thoracic duct empties at the junction of the subclavian and internal jugular veins, lying between the latter vein and the subclavian artery behind (see Figs. 31 and 38). Still further outward lie the scaleni antici muscles, and phrenic nerves on each side of the neck. At a deeper level lie on each side the subclavian arteries which pass across the first rib behind the scaleni antici, between these muscles and the brachial plexus, situated posterior to them. The subclavian arteries form an arch whose course is from the sternoclavicular joint on each side, to the middle of the corresponding clavicle, the summit being one and a half inches above the latter bone. Beneath this arch, in close relation with the subclavian artery above and the brachial plexus on the outer side, is the apex of the pleural cavity (see Figs. 31 and 41). Aneurisms of the subclavian artery may press upon the apex of the lung lying below it, upon the vagus in front, and the recurrent laryngeal on the right side, where it arches beneath it to reach the lateral aspect of the trachea (see Fig. 43). The subclavian artery is most frequently ligated in its third portion, which can be readily found if it is remembered that this lies external to the scalenus anticus (the vein in front), that is, a little to the outer side of the posterior border of the sternomastoid.

The chief branches of the subclavian artery are given off in its first portion, *i. e.*, to the inner side of the scalenus anticus. The vertebral and internal mammary lie internally, and the thyroid axis externally; the inferior thyroid branch of the latter passes upward, then transversely across to the trachea, passing between the carotid sheath and vertebral artery (see Figs. 31 and 38). The vertebral passes to the transverse process of the sixth cervical vertebra, accompanied by the vein. It can be reached by an incision along the posterior border of the sternocleidomastoid, pulling the carotid sheath inward, and dissecting down to the transverse process of the sixth cervical (see Fig. 33).

**Deep Cervical Fascia.**—It has already been seen that the **outer layer** starts in the median line behind, and meets again at the median line in front after inclosing the trapezius and sternomastoid muscles and submaxillary gland on each side (see Figs. 33 and 41). The **middle or previsceral layer** begins also in the median line behind, gives off lamellæ to inclose the muscles at the back of the neck, and passes forward, forming the carotid sheath inclosing the common carotid, internal jugular vein, vagus, and a number of deep cervical lymph-glands, and


Fig. 42.—View of heart and large blood-vessels of thorax and neck in adult. 1, Upper border of thyroid cartilage, opposite which the common carotid divides into the internal and external carotid arteries. 2, Common carotid artery. 3, Internal jugular vein. 4, External jugular vein. 5, Upper rings of trachea. 6, Subclavian artery. 7, Subclavian vein. 8, Arch of aorta. 9, Superior vena cava. 10, Lateral lobes of thyroid gland. R.B., Right bronchus. L.B., Left bronchus. P, Pulmonary artery. xxx, Tricuspid valve. A, Aortic valve. M, Mitral valves. The arrow passing up the aorta shows the direction in which aortic murmurs are transmitted. The arrow beginning at M, and directed toward the apex of the heart, shows the direction in which mitral murmurs are transmitted. P, Position of pulmonary valve.

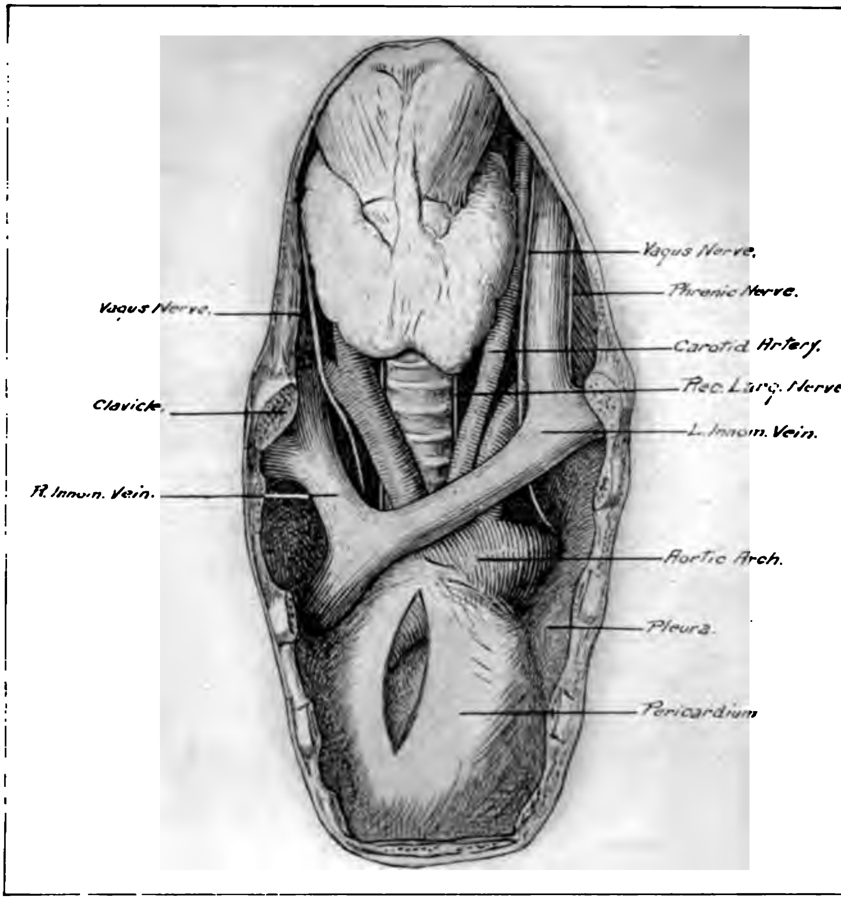


Fig. 43.—View of relations of thyroid to recurrent laryngeal nerves, and of vessels at base of neck to pericardium. (Modified from Hildebrand.)

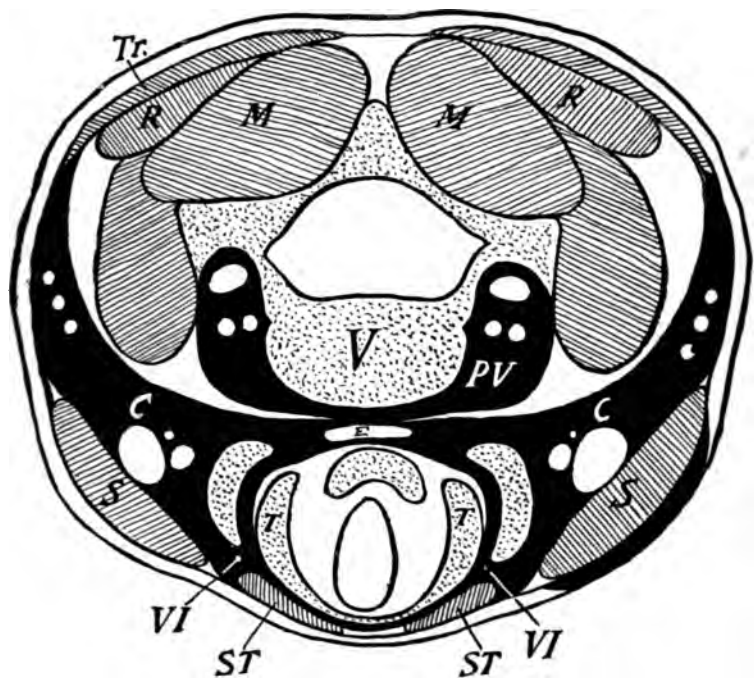


Fig. 44.—Mode of spreading of infection in deep cervical fascia. *ST*, Sternothyroid and hyoid muscles. *S*, Sternocleidomastoid muscle. *R* and *M*, Deep muscles at back of neck. *Tr*, Trapezius muscle. *V*, Body of cervical vertebra. *C*, Structures of carotid sheath. *E*, Esophagus. *T*, Thyroid cartilage, and opening of larynx. *VI*, Connective tissue of free visceral space. The black shading shows direction in which pus can spread. *PV*, Mode of spreading of pus in free vertebral layer.


Fig. 45.—Paralysis of the right trapezius muscle, as a result of cutting the spinal accessory nerve during an operation for tubercular glands of the neck. *P*, points to the paralyzed muscle. Observe the depression on the right side of the neck (paralyzed side).

also the omohyoid. It then passes behind the sternohyoid and thyroid muscles, lying in front of the trachea and thyroid gland (hence, called previsceral), being continuous across the median line with the same layer of the other side (Figs. 33 and 41). Its upper border is the hyoid bone; its lower, after inclosing the brachiocephalic vein, passes on into the anterior mediastinum, becoming continuous with the pericardium (see Fig. 35). An abscess situated between this layer and the outer passes in front of the trachea and down to the anterior mediastinum, causing an abscess there. The deepest layer of the fascia, or **prevertebral,** begins at the transverse processes of the cervical vertebræ, where it is continuous with the middle or previsceral layer (Fig. 33). It then passes back of the pharynx and esophagus, being attached above to the basilar process of the occipital bone (see Figs. 33 and 35), and laterally to the transverse processes of the cervical vertebræ. Below, it becomes continuous with the cellular tissue of the posterior mediastinum. Between it and the vertebral column there is a space wider above than below, the retropharyngeal. It is the seat of both acute (due to lymph-glands) and chronic abscesses (latter due to tuberculosis of vertebræ). These abscesses, unless opened, have a tendency to gravitate down behind the esophagus to the posterior mediastinum (Fig. 35).

**Cut Throat.**—Wounds resulting from suicidal attempts are most common through the thyrohyoid space; here the lingual, facial, and superior thyroid arteries are liable to be injured, and there is also danger of asphyxia from aspirated blood. The next most common place is through the trachea, where the vessels in the carotid sheath and inferior thyroid arteries and recurrent laryngeal nerves may be injured.

**Air in Veins.**—Not infrequently, during operations for the removal of tumors of the neck, especially those which lie in close contact with the carotid sheath, or in the extirpation of lymph-glands which are adherent to the internal jugular vein, the latter is opened and air aspirated. The danger from the entrance of air into veins has been greatly exaggerated, and some of the cases which were formerly supposed to have resulted in death are now believed to have been cases of infection with a gas-producing bacillus. However, should the air enter the vein, a peculiar hissing noise is heard and the air is aspirated into the ventricles, causing death through distention of the right ventricle.

**Lateral Region of Neck.**—This is bounded in front by the sternomastoid muscle; behind, by the trapezius; and below, by the clavicle and acromion. The **skin and subcutaneous tissue** show the same characteristics as in the anterior region, except in the upper part, where

the skin is thick and inelastic like that of the posterior region, and is a frequent seat of furuncles. Such superficial abscesses (boils), on account of the firmness of the connective tissue, cause tense infiltration of the latter, resulting in an almost board-like consistency. Necrosis of this tissue occurs, giving rise to the so-called "core" of these abscesses (pseudo-carbuncles). The fascia covering this region is continuous with that of anterior and posterior regions, being limited at the sternocleidomastoid and trapezius muscles, which it incloses (Figs. 33 and 41). Abscesses, *e. g.*, from the cervical vertebræ situated under this fascia, are limited in front and behind by the above-mentioned attachments to these muscles and the clavicle. The lateral region corresponds to the posterior triangle of the neck, and has the same boundaries. The superficial layer contains a large number of lymph-glands, which drain the ear and back of the head, and are often the seat of tuberculosis. In this same layer the external jugular vein can be seen passing from the angle of the jaw to the middle of the clavicle, lying just beneath the skin and external to the fascia until just above the clavicle, where it pierces the fascia to empty into the subclavian vein (see Figs. 30, 33, and 41). At about the middle of the posterior border of the sternomastoid muscle various nerves emerge from behind the muscle to pass across this region. The spinal accessory emerges at this point and crosses obliquely to the anterior border of the trapezius, entering it opposite the seventh cervical vertebra. Beginning from above downward, the occipitalis minor (see Figs. 5 and 30) passes to the back of the head, supplying it with sensation. The auricularis magnus passes upward to the back of the ear, supplying that region. The superficial cervical passes across the outer surface of the muscle to supply the front of the neck. The three supraclavicular branches of the superficial cervical plexus pass downward (see Figs. 23 and 30). In caries of the cervical vertebræ pain is often referred to the skin supplied by these nerves. In the **deeper layer** of this region the phrenic nerve can be seen passing parallel to the posterior border of the sternomastoid, behind the end of the innominate vein into the thorax (best place to apply electrode is posterior border of the sternomastoid). The brachial plexus passes obliquely down and outward, between the scalenus anticus and medius muscles (see Figs. 31 and 33). The subclavian artery is seen at the lower part of this region, crossing the first rib behind the scalenus anticus, while the vein passes in front of it. This is the best place to ligate or compress the subclavian artery, *i. e.*, against the first rib. The thoracic duct forms a curve with convexity upward just above the middle of the clavicle and empties a little

behind the posterior border of the sternomastoid, at the point of junction of the internal jugular and subclavian veins (see Fig. 38). In this deep layer, lying upon the scaleni muscles and brachial plexus, and beneath the sternomastoid, are a number of deep cervical lymph-glands, which are frequently firmly adherent to the internal jugular, rendering it difficult to avoid injury to the vein in their removal. They bear a close relation to the axillary glands and to the mammary lymph-vessels, and are of great importance in malignant processes of that organ (see Figs. 39 and 62). They receive the lymph from the upper deep glands, and, in addition, that direct from the larynx, trachea, esophagus, and thyroid. The apex of the pleural cavity lies beneath the subclavian artery and brachial plexus (Fig. 33). The posterior region will be taken up in the section upon the Spine.

# THE THORAX.

The **bony thorax** is formed by the sternum, ribs, and dorsal vertebræ. These bony limits do not correspond with those of the true thorax, which is the cavity containing the heart, lungs, large blood-vessels, and esophagus. This **true thorax** is bounded above by the apices of the pleural cavity, around which lie the vessels, etc., at the lower portion of the neck (see Figs. 38, 41, 42, 43). Laterally, it has as its limits the sternum, dorsal vertebræ, and all of the ribs lying above the attachment of the diaphragm. The latter muscle constitutes the base of the cone which the thorax forms. The sides of this cone are flattened in an anteroposterior direction. The apex of the convexity of the diaphragm is so high on each side (level of fourth rib on right side, and of fifth rib on left side) that quite a large proportion of the abdominal viscera lie within the limits of the bony thorax (see Fig. 46). The normal adult thorax is elliptical in shape on cross-section (see Fig. 47), being larger in its transverse than in the anteroposterior diameter. In the child it is nearly circular in outline. The best point to measure the circumference of the chest is at the level of the nipples. The **shape of the thorax** may be generally changed, as the result:

A. Of **occupation**; sailors, shoemakers, and carpenters often show a marked depression at the lower end of the sternum.

B. **Diseases of air-passages.**

(*a*) In emphysema the anteroposterior diameter tends to equal the transverse, giving the chest a circular (reversion to infantile type) or barrel shape (Fig. 47).

(*b*) In tuberculosis; often preceding actual development of disease there is decrease of the anteroposterior diameter, or flat chest.

(*c*) Chronic obstruction in the nose or mouth (adenoids or enlarged faucial tonsils)—the sides of the thorax are flattened.

C. **Spinal column.**

(*a*) In Pott's disease of the dorsal region the anteroposterior diameter is frequently greatly increased, and the obliquity of the entire thorax, especially of the ribs, is so changed that the latter often touch the pelvis (see Fig. 164).

(*b*) Lateral curvature. This may cause a change in the diameters, so that the anteroposterior diameter runs in an oblique direction, opposite to that of the curvature (Fig. 47).

D. **General disease.** Rickets may either cause the sternum to project (pigeon-breast) with flattening of the sides, or it may cause a

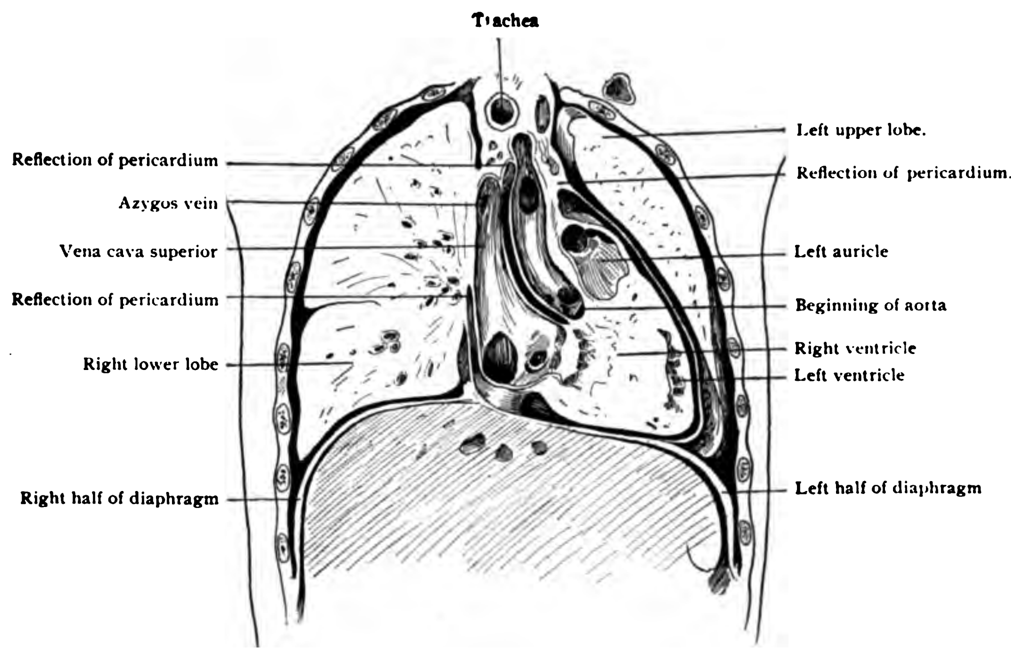


**Fig. 46.**—Coronal section of thorax and upper portion of abdomen, to show relation of liver to subphrenic space and of right lobe of lung to diaphragm and liver. (After Henle.)

retraction in the transverse diameter, giving a quadrilateral aspect to the chest. This is accompanied by prominences (rachitic rosary) at the junction of the costal cartilages and ribs.

In addition to the above bilateral changes in form, there may be only unilateral; for example, the prominence over an aneurism, or the de-

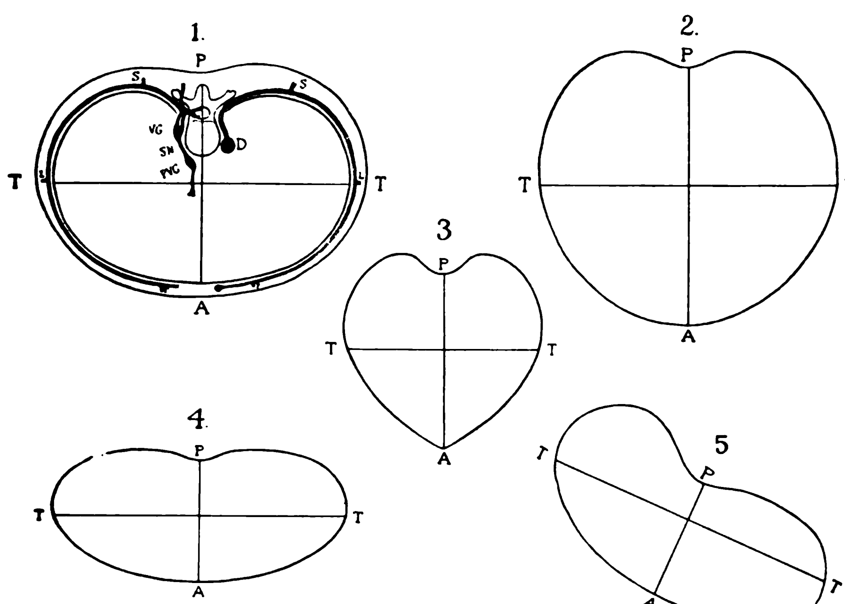


Fig. 47.—Cross-sections (diagrammatic) of normal and pathologic chests. 1, Normal chest. Anteroposterior diameter (AP) less than transverse. On the right side of the thorax the distribution of a typical intercostal nerve is shown with its three branches, posterior (S), lateral (L), and anterior (F). The relation to the sympathetic is shown. VG, Vertebral ganglion. PVG, Prevertebral ganglion. Upon the left side of the thorax the distribution of a typical intercostal artery is shown. D, Descending or thoracic aorta. S, Posterior. L, Lateral, and F, Anterior branches of the anterior and posterior intercostal arteries, the anterior being derived from the internal mammary, near F. 2, Emphysematous chest. On account of its barrel-shape the anteroposterior almost equals the transverse diameter. 3, Rachitic or pigeon-breast. Anteroposterior greater than the lateral diameter. 4, Flat or tubercular chest. Anteroposterior much less than the lateral diameter. 5, Scoliotic chest. Diameters are oblique.

formity of the chest following hypertrophy of the heart in young people, there being a decided prominence over the region of the heart. On the other hand, the entire side may be more prominent, as the result of contraction of the opposite lung.

In the **examination of the thorax in the living,** the following points are to be noted:

1. Palpate the sternum, beginning with the notch known as the suprasternal, situated between the two clavicles; passing downward along the sternum, one can feel a prominence which is an important landmark in counting the ribs. This is situated at the junction of the manubrium and gladiolus, and corresponds to the level of the second costal cartilage and rib. At the lower end of the sternum palpate the xiphoid cartilage. It is often bent inward, as the result of occupation, or may be curved outward, causing it to become quite prominent.

2. Palpate the ribs. This can be done quite easily, except in fat individuals. The first rib lies so deeply under the clavicle that it can only be felt behind the latter. Here the pulsations of the subclavian artery can be detected. The remaining ribs can be readily felt, except the last two floating ribs, for which it is necessary to palpate deeply and close to the spine. Note the obliquity of the ribs, and that the end of the rib in front is considerably below its level at the spine. In children it is of great importance to palpate at the junction of the ribs and costal cartilages, so as to become accustomed to the normal prominence, as distinguished from the rachitic enlargement at this point.

3. Palpate the breasts. In the male they are quite rudimentary; in the female they extend from the third to the seventh ribs. The nipple lies in the fourth intercostal space, in a line drawn from the middle of the clavicle downward.

4. Palpate the chief muscle of the thorax, the pectoralis major, whose lower margin, as it slopes upward to form the anterior wall of the axilla, can be rendered quite prominent by bringing the arm to the side of the chest. In the same manner, palpate the corresponding muscle on the back of the chest, which forms the posterior wall of the axilla, the latissimus dorsi.

5. When the patient's arm is brought upward toward the head, note the serrations of the serratus magnus on the side of the chest.

6. Palpate the coracoid process, just below the outer end of the clavicle. Also the sternoclavicular and acromioclavicular joints.

7. Palpate the apex-beat, and note its position just inside of the midclavicular line in the fifth intercostal space. In children it is generally situated in the fourth intercostal space.

For the sake of convenience certain lines are used in order to locate the organs, etc., contained in the thorax (see Fig. 49).

1. Sternal line. Drawn vertically through middle of sternum.

2. Lateral sternal lines. Drawn through sides of sternum.

3. Parasternal line. Drawn midway between the lateral sternal and mammary lines.


Fig. 48.—Method of counting the ribs for the purpose of determining the level of fluid, etc., in the pleural cavity. One usually begins by palpating the angulus Ludovici or prominence at the junction of the first and second portions of the sternum, that is, of the manubrium and gladiolus. By passing the fingers outward one touches the second rib. From this point down the remainder of the ribs can be readily counted.

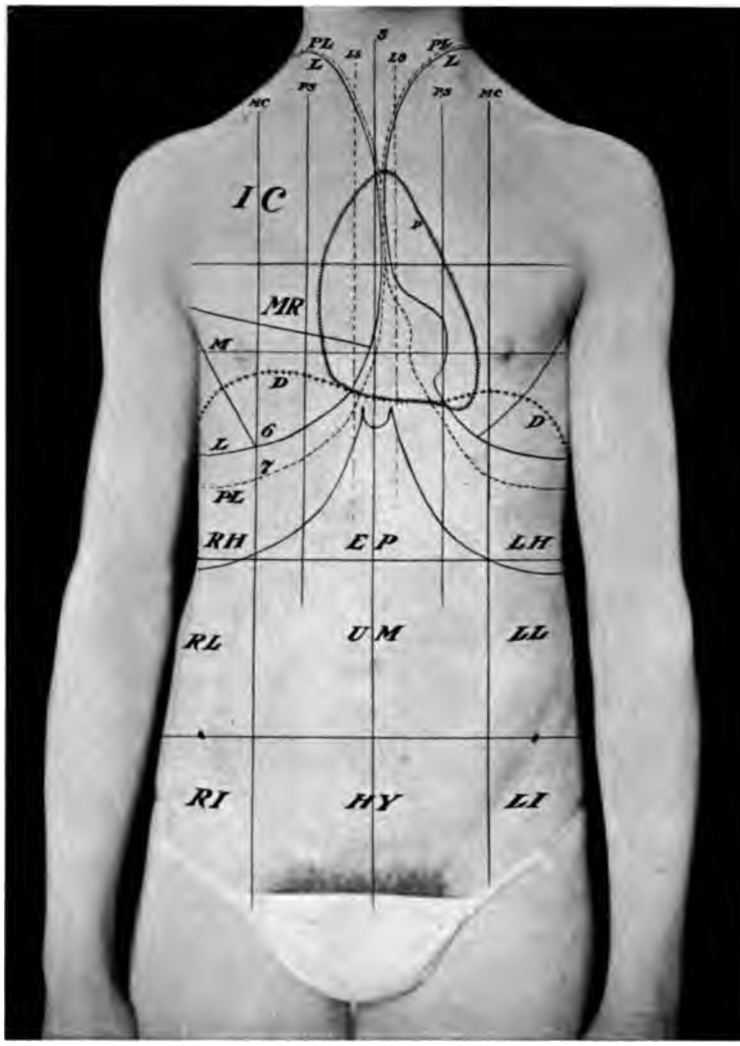


Fig. 49.—Surface markings of pleuræ, lungs, pericardium, and fissures of lungs; also divisions of abdomen. S, Sternal line. LS, Lateral sternal line. PS, Parasternal line. MC, Midclavicular line. IC, Infraclavicular region. MR, Mammary region. M, Transverse mammary line. PL, Pleura, crossing midclavicular line at seventh rib. Its relation to the pericardium should be noted. L, Surface outline of lungs following closely that of pleura. It crosses the sixth rib at the midclavicular line. P, Pericardium outlined. Its relation to the pleura should be followed. D, Diaphragm. The interlobar fissures are seen upon the right and left sides, showing that upon the right side the right upper, middle, and lower lobes come to the surface of the chest; upon the left side the left upper and lower. RH, Right hypochondriac region. EP, Epigastric region. LH, Left hypochondriac region. RL, Right lumbar region. UM, Umbilical region. LL, Left lumbar region. RI, Right iliac region. HY, Hypogastric region. LI, Left iliac region.

4. Mammary or midclavicular lines. Drawn vertically through nipples from middle of clavicle.

5. Axillary line. Drawn vertically from apex of axilla downward.

6. Scapular line. Drawn vertically through angle of scapula.

7. Anterior axillary line. Drawn from junction of pectoralis major and axilla downward.

8. Posterior axillary line. Drawn from junction of axilla and latissimus dorsi downward.

That portion of the thorax which lies above the clavicle in front is called the supraclavicular region; that below the clavicle as far as the third rib is called the infraclavicular region or fossa. From the third to the sixth ribs is called the mammary region. The region below the sixth rib is called the inframammary region. Between the anterior and posterior axillary lines we have, from the apex of the axilla to the sixth rib, the axillary region; from that point downward, the infra-axillary region. Above the spine of the scapula is the suprascapular region. Below the spine of the scapula is the infra-scapular, and between the vertebral borders of the two scapulæ, the interscapular region.

## Surface Markings of the Thoracic Organs.*

**Pleuræ.**—Beginning at the sternoclavicular joint on each side, the surface markings of the pleura correspond to a line drawn from each sternoclavicular joint to the prominence at the junction of the first and second portions of the sternum (see Fig. 49). The two pleuræ then run parallel to each other, the right passing a little beyond the median line. The space between them corresponds to the location of the anterior mediastinum. At the fourth rib the left pleura leaves the sternum and passes outward in an oblique manner, following the left border of the sternum to the sixth costal cartilage. The space thus left between it and the sternum corresponds to that portion of the pericardium which is in contact with the chest-wall. On the right side the pleura continues almost to the ensiform process, and then passes gradually outward, crossing the lower border of the seventh rib in the mammary line, the ninth rib in the axillary, and the eleventh near the spine (see Figs. 49, 50, 51, and 52).

The upper markings of the pleura are a line drawn obliquely upward and outward from the sternoclavicular joint across the lower portion of the neck, in such a manner as to curve upward, and reach the spine at the level of the vertebra prominens. The highest point of this

* The student is advised to outline these surface markings under the supervision of the instructor.

curve is an inch and a half above the clavicle. This corresponds to the apex of the pleural cavity. Posteriorly, both pleuræ (see Fig. 50) follow close to the spinal column from the vertebra prominens to the eleventh rib below, curving downward and outward so as to extend almost to the tip of the twelfth rib. (See Abdomen.)

**Lungs.**—The surface markings of the lungs correspond closely to those of the pleura, above and in the median line, both on the left and right sides. The only difference is that the lower borders of both lungs are the sixth rib in the mammary line, the eighth rib in the axillary, and the tenth rib behind (see Figs. 49, 50, 51, and 52). The interval between the lower surface marking of each lung and its pleura corresponds to the complementary space or sinus of the pleura. During inspiration the lower margins of the lungs move downward almost as far as the above-mentioned lower limits of the pleuræ; namely, seventh rib in the mammary line, ninth rib in the axillary, and eleventh rib posteriorly. In marking the normal chest, it is advisable to let the patient take a deep breath, and note by percussion this respiratory excursion of the lung.

The lower surface markings of the pleura correspond to the insertions of the diaphragm into the chest-wall.

**Trachea and Bronchi.**—The tracheal surface marking corresponds to a broad line (Figs. 49 and 53) drawn from the upper margin of the sternum to the level of the second rib in the median line. At this point the trachea divides into the two main bronchi, the right and the left, the surface markings of which correspond to a line passing downward and outward from this point.

**Aorta.**—The aorta corresponds to a line drawn from the junction of the third left costal cartilage and sternum to the upper border of the second costal cartilage on the right side. It then crosses obliquely (Fig. 42) in the median plane of the chest, to reach the vertebral column on the left side of the upper dorsal vertebra (Fig. 50).

**The pulmonary artery** corresponds to a line drawn from the second left intercostal space to the second left costal cartilage, where it bifurcates (Fig. 53). The right ventricle under normal conditions is the only portion of the heart in immediate contact with the chest-wall. Only the edge of the left ventricle is visible. The **pulmonary orifice** is opposite the junction of the third left costal cartilage with the sternum; a little lower are the **aortic valves** (see Fig. 53). The **mitral and tricuspid** valves lie almost under the fourth intercostal space, close to the left border of the sternum, the tricuspid lying behind the sternum a little lower than the mitral.

**Interlobar Fissures.**—The surface marking of the fissure between

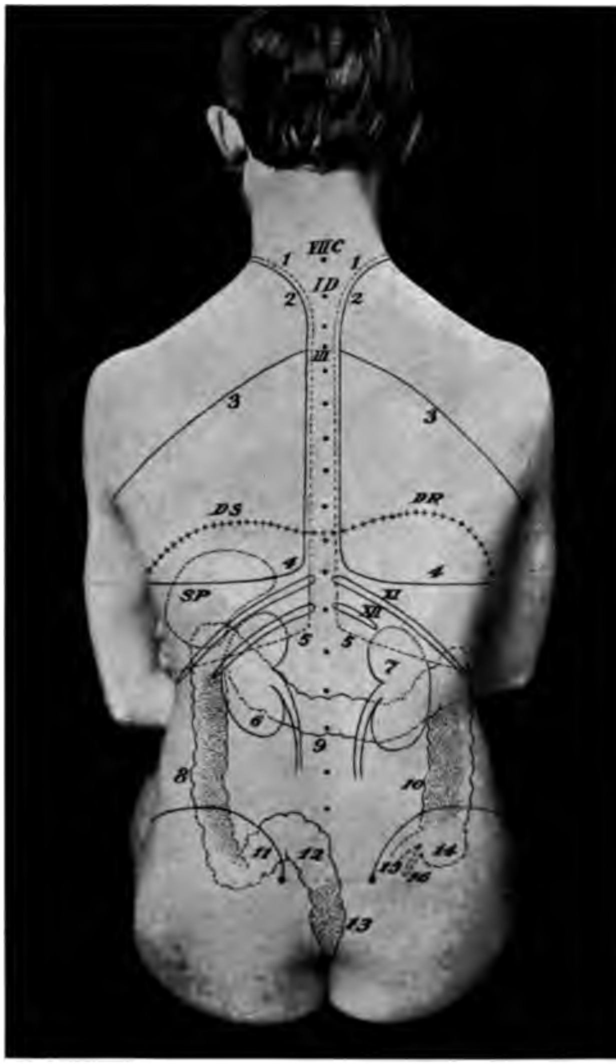


Fig. 50.—Surface markings of pleuræ, lungs, interlobar fissures, and relations of the pleural cavities to kidneys. 1, Apical and mediastinal pleura. 2, Upper and posterior margins of lungs. 3, Interlobar fissure between upper and lower lobes on each side. 4, Lower border of lung. 5, Lower border of pleura. 6, Left kidney. 7, Right kidney. Upon the right side observe a short twelfth rib, as not infrequently occurs, lying entirely within the pleura. Upon the left side the ribs are shown in the normal or average length (see text). 8, Descending colon. 9, Transverse colon. 10, Ascending colon. 11, Iliac colon. 12, Pelvic colon—11 and 12 are usually described together as the sigmoid flexure. 13, Rectum and anal canal. The extraperitoneal portions of the ascending and descending colon and rectum are represented by the finely dotted areas. DS, Left dome of diaphragm. DR, Right dome of diaphragm. SP Spleen. 14, Cecum. 15, End of ileum. 16, Appendix.


**Fig. 51.**—Surface markings of thoracic and abdominal viscera viewed from the left side; also view of Roser-Nélaton line. C.C., Costo-clavicular line. Ax, Mid-axillary line. U.L., Upper lobe of lung. L.L., Lower lobe. 2, Lower margin of lung. 3, Lower margin of pleura. 4, Anterior superior spine of ilium. 5, Costal arch. S, Spleen. T.C., Transverse colon. D.C., Descending colon. S.F., Sigmoid flexure (iliac colon). R.N., Roser-Nélaton line passing from 4 across top of trochanter major (T) to tuberosity of ischium (Is.).


Fig. 52.—Surface markings of thoracic and abdominal viscera (right side). U.L., Upper lobe of right lung. L.L., Right lower lobe. M.L., Middle lobe. 1, Upper border of liver. 7, Lower border of liver. 2, Lower border of lung. 3, Lower border of pleura. 4, Fissure between right lower and middle lobes. 5, Fissure between right upper and middle lobes. 6, Gall-bladder. T.C., Transverse colon. A.C., Ascending colon. A.Sp., Anterior superior spine of ilium. Ax, Mid-axillary line.

the upper and lower lobes of the right lung is a line drawn from the third dorsal spine obliquely downward in such a manner as to reach the sixth rib close to the midclavicular line (Figs. 49 and 50).

That between the upper and lower lobes on the left side is exactly the same. On the right side, as this interlobar fissure between the right upper and lower lobes passes forward, it forms the boundary-line from the posterior axillary line onward, between the middle and lower lobes (see Fig. 52). The interlobar fissure between the upper and middle lobes of the right lung corresponds to a line drawn from the apex of the axilla almost horizontally to the sternum, reaching the latter at about the level of the fourth costal cartilage (see Fig. 49). In accordance with the course of these interlobar fissures, the following lobes of the lung are in relation with the chest-wall. Anteriorly, on the right side, the upper, middle, and lower lobes. On the left side, upper and lower lobes (Fig. 49). In the axilla on the right side, middle and lower lobes (Fig. 52). On the left side, upper and lower lobes (Fig. 51). Posteriorly, only the upper and lower lobes of both lungs are in relation to the chest-wall (Fig. 50).

**Pericardium.**—The upper border of the surface marking of the pericardium corresponds to the junction of the first and second portions of the sternum; that is, the level of the second rib (Fig. 49). It then passes to the right almost as far as the parasternal line, and to the left in an oblique manner toward the midclavicular line and apex of the heart. It is somewhat elliptical in shape, a portion coming in direct contact with the diaphragm just behind the ensiform process and fifth costal cartilage on the left side.

The **skin of the thorax** is thicker than that of the face and neck. It is loosely attached, except over the sternum. In its upper part are many sebaceous glands, which are frequently the seat of an acne. The subcutaneous tissue over the front and side has a loose-meshed structure; over the back, a much firmer and closer. Hence, subcutaneous phlegmons spread rapidly through the former. It contains a considerable amount of fat, especially over the pectoral muscles. Lipomata not infrequently develop in this fat over the back of the thorax. The principal muscles are (1) the pectoralis major, which arises from the sides of the sternum, and the upper six costal cartilages (sternal portion), and also from the inner end of the clavicle (clavicular portion), and passes across to the upper portion of the humerus; (2) the pectoralis minor; (3) the serratus magnus; (4) the latissimus dorsi; (5) the external and internal intercostals.

incisions for abscess of the gland should radiate from the nipple. The various forms of benign growths which occur here are chiefly fibroma and adenoma; of malignant growths, carcinoma (most frequent) and sarcoma. Carcinoma, on account of the rich lymphatic supply, gives rise to metastases early. The modern operation of Halsted aims to remove the gland and integument in sufficient amount to include the superficial lymphatics, the pectoralis major, pectoralis minor, all glands and fat in the axilla, and, in doubtful cases, the glands of the posterior cervical triangle. The operation, as ordinarily performed, consists in making an elliptical incision well away from the nipple, prolonged to the axilla. The mammary gland, deep pectoral fascia, and entire axillary fat and glands are removed. The breast may also be the seat of a tuberculosis.

## The Diaphragm.

The diaphragm separates the abdominal from the thoracic cavity, its convexity being upward (see Figs. 46, 49, 50, 51, and 52). It consists of a peripheral muscular, and a central tendinous portion, the former being attached to the inner aspects of the xiphoid and lower ribs, and the anterior surfaces of the upper two lumbar vertebræ. Its upper surface is covered by the diaphragmatic pleura on each side, and the pericardium in the middle, and is in contact with the heart and lungs (see Figs. 49 and 67). Its lower surface is covered by peritoneum, and is in contact with the liver, the spleen, stomach, and kidneys (see Figs. 47, 68, and 69). Just in front of the spinal column it has an opening for the aorta (accompanied by the vena azygos and thoracic duct). In front and to the left of the aortic opening is one for the esophagus and vagi (see Fig. 69). Still higher and nearer the center is an opening for the vena cava. The diaphragm is supplied by the phrenic nerve, and by the internal mammary artery on its upper surface and phrenic artery on its lower surface.

## The Pericardium.

The pericardium (see Figs. 49, 55, and 71) is a closed sac, in which the heart and large blood-vessels have been placed. The visceral layer is thin, covers the heart and extends up about 2 cm. along the proximal end of the aorta and other large vessels arising from the heart (Fig. 43). The parietal layer is much firmer. It is attached to the sternum in front and the fifth costal cartilage where the two layers of mediastinal pleura recede. Below it is attached to the central tendinous portion of the diaphragm, and laterally to the mediastinal pleuræ. The cavity between the two layers contains a small amount of serum normally.

Behind, the pericardium is in contact with the esophagus and vessels of the posterior mediastinum (Fig. 55). This cavity is the seat of effusions which tend to displace the heart toward the median line. Paracentesis is performed through the fifth or sixth space 1 inch to the left of the sternum, and the fifth costal cartilage is resected to drain a pericardial exudate (pericardotomy). The parietal pleura almost covers the pericardium (see Fig. 68), and must be pushed to the left.

## The Heart.

The heart (for surface markings, see Fig. 68) is cone-shaped, with base upward (see Figs. 37, 53, and 71). It is divided by a vertical septum into two lateral halves. This is indicated in front and behind by a groove, in which the coronary vessels run. Each half is again divided by a horizontal septum into an upper or auricular and a lower or ventricular portion. The right half is the venous, the left the arterial, portion. The large systemic veins empty into the right upper division (right auricle). Into the left auricle empty the four pulmonary veins. The septum between the two auricles shows a depression corresponding to an opening (foramen ovale) existing during fetal life and often several months after birth, permitting free communication between the two auricles.

The ventricles and auricles communicate by an orifice provided with three valves on the right (tricuspid), and with two on the left side (mitral). Opening from the right ventricle, which lies in contact with the sternum, is the pulmonary artery; from the left ventricle (situated immediately behind the pulmonary orifice) the aorta begins. The heart itself is supplied by the coronary arteries, which begin behind the semilunar valves of the aorta; the nerves are derived from the vagi and sympathetics. The former depresses or slows the heart, the latter stimulates or accelerates it. The heart lies in the anterior mediastinum (separated from the sternum by the anterior borders of the lungs), between the sternum and vertebral column. Its long axis is directed from the right above to the left downward and forward (Figs. 37 and 53). A left-sided pleural effusion displaces the heart to the right. Wounds of the heart most frequently involve the right ventricle. A number of successful cases of suture of the heart have been reported. In order to expose it, the fourth and fifth left costal cartilages must be resected, and, if necessary, a portion of the sternum adjacent. In children the heart is relatively larger than in adults (Figs. 37 and 71) and the apex-beat is higher.

## The Esophagus.

The esophagus (see Fig. 69) begins at the cricoid cartilage as the

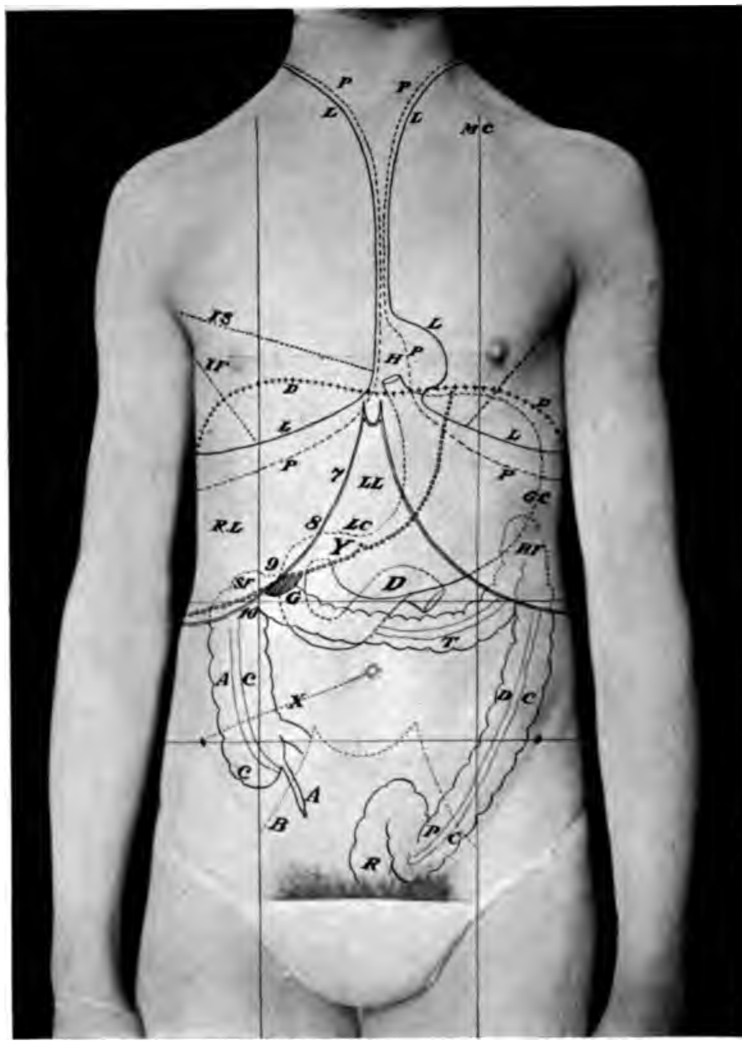


Fig. 68.—Surface markings of thoracic and abdominal viscera. P, Pleura. L, Lung. MC, Midclavicular line. D, Upper level of diaphragm. RL, Right lobe of liver. LL, Left lobe of liver. LC, Lesser curvature of stomach. GC, Greater curvature of stomach. Y, Pylorus. G, Gall-bladder. SF, Hepatic flexure of colon. HF, Splenic flexure of colon D, Ascending portion of duodenum. The horizontal and vertical portions of the duodenum can be followed from Y to D. The vertical portion is under the letter G. AC, Ascending colon. C, Cecum. A, Appendix. B, Pelvic brim, projected on anterior surface of abdomen. X, McBurney's line, from anterior superior spine of ilium to umbilicus. T, Transverse colon. DC, Descending colon. PC, Pelvic colon or sigmoid flexure. R, Rectum. IS, Fissure between upper and middle lobes of right lung. IF, Fissure between middle and lower lobes of right lung. H, Portion of pericardium which is not covered by pleura (P). The figures 7, 8, 9, and 10 are placed opposite the costal cartilages of the respective ribs.

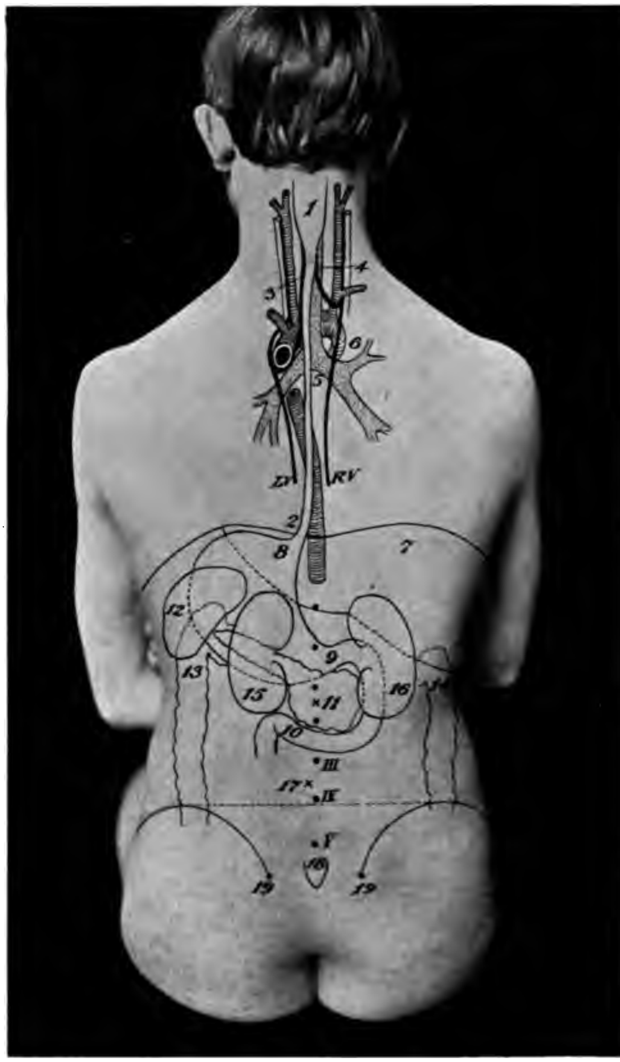


**Fig. 69.**—Relations of trachea, esophagus, vagus, and aorta; also surface markings of chief abdominal viscera, seen from behind. 1, Pharnyx. 2, Esophagus. Note how it passes toward the left in the thorax before penetrating the diaphragm. 3, Left recurrent laryngeal nerve, arising from the vagus beneath the arch of aorta. 4, Right recurrent laryngeal, arising from vagus and arching around right subclavian to reach space between esophagus and trachea. 5, Bifurcation of trachea. Note shorter right, and longer left main bronchus. 6, Placed to the right of the ascending portion of arch of aorta, which can be followed to the left after giving off its upper branches to the neck and upper extremity. It is interrupted in its course to show how it arches over the left bronchus and continues as the thoracic aorta. 7, Liver. 8, Cardiac portion of stomach. 9, Pyloric portion. 10, End of ascending portion of duodenum, just before passing into jejunum. Between 9 and 10 the duodenum can be followed in its relation to the kidney. 11, Head of pancreas. 12, Spleen. 13, Descending colon. 14, Ascending colon. Just above the last two numbers are seen the splenic and hepatic flexures respectively. 15, Left kidney. 16, Right kidney. 17, Favorite point for lumbar puncture (see text). 18, Termination of dural sac at third sacral vertebra. 19, Posterior superior spine of ilium. LV, Left vagus nerve. RV, Right vagus nerve.

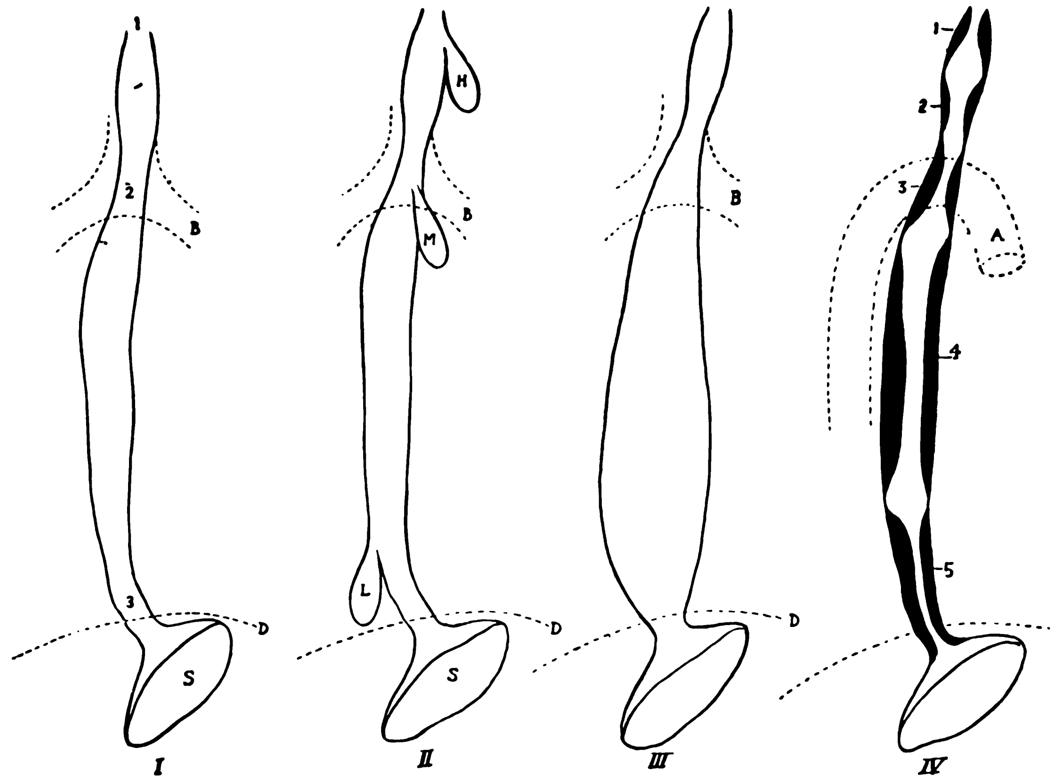


Fig. 70.—Normal and pathological conditions of the esophagus. In all of the diagrams B represents the bifurcation of the trachea into the two main bronchi; D, is the diaphragm, and S, cardiac end of the stomach. I, Normal esophagus showing the normal point of narrowing at its junction with the pharynx. (1) Opposite the bifurcation of the bronchi; (2) at the diaphragm. II, Location of most frequent diverticula of the esophagus. H, Cervical form of vulsion or pressure diverticulum. N, Location of traction diverticulum opposite bifurcation of bronchi. L, Location of diverticulum close to cardiac end of stomach. III, Sacculated condition of esophagus or so-called idiopathic dilatation as the result of spasm of the cardiac end of the esophagus (cardiospasm). IV, Diagrammatic representation of most frequent seats of stenosis or stricture of the esophagus. A, Arch of aorta. (1) Stenosis as a result of carcinoma of the lower end of pharynx and beginning of esophagus. (2) Stenosis as a result of pressure from tumors of the neck. (3) Stenosis as a result of aneurism of the arch of the aorta. (4) Stenosis as a result of caustic or lye strictures. These latter may extend along the entire length of the esophagus. (5) Stenosis as a result of carcinoma of the lower end of the esophagus and cardiac end of stomach.

to the left of the median line (Fig. 50), then in front of the dorsal vertebra, through the esophageal orifice of the diaphragm to the stomach (cardiac end) (Figs. 33, 38, 54, 55, and 69). It is 23 cm. to 26 cm. (9 to 10 inches) long; in children, 17 cm. The esophagus is normally narrower in some portions than in others. The three narrowest portions are the most frequent seats of stricture. They are:

1. Just at the cricoid cartilage.
2. Seven centimeters below this.
3. Just before entrance into the stomach.

It is divided into a cervical, a thoracic, and an abdominal portion. Its cervical relations were given above (see Neck). In the thoracic portion it lies behind the aorta, and is liable to be compressed by aneurism of the same; hence the passage of sounds in this condition is quite dangerous for fear of perforating the vessel. It next lies behind the left bronchus (Fig. 69). Careless passage of sounds in carcinoma may cause a communication between the bronchus and esophagus to be made. To the right lies the great vena azygos. Foreign bodies may penetrate the latter also.

The veins (Fig. 90), especially at the lower end, may be enormously dilated, and varicose in case of obstruction to the portal circulation owing to nature's attempt to create a collateral circulation between the veins of the stomach and those of the esophagus (emptying into azygos and pericardiac veins), giving rise, if a rupture occurs, to severe hemorrhage (hematemesis).

The **pulmonary artery** (Fig. 53) arises on the anterior surface of the heart, from the right ventricle, lies just in front of the aorta, and passes upward to divide into its right and left branches. It is connected with the aorta by a ligament which represents the obliterated ductus Botalli of fetal life.

The **arch of the aorta** consists of three portions, the ascending, the transverse, and the descending. The ascending lies behind the pulmonary artery at the level of the third costal cartilage, being separated from the sternum by the pericardium only, which covers it for about 5 cm. (2 inches) (Figs. 43, 53, and 54). If an aneurism exists in the ascending portion, it may rupture into the pericardial cavity. The transverse portion of the arch passes from a point corresponding to the first right interspace directly backward in the mediastinum to the left side of the vertebral column (Fig. 54), giving off three branches (innominate, left common carotid, and subclavian arteries). The descending or thoracic aorta begins at the third dorsal vertebra and passes along the median line to the aortic opening in the diaphragm (Fig. 69). The arch of the

aorta is the most frequent seat of an aneurism. It may grow forward to the sternum, absorbing the latter and appearing as a pulsating tumor just at the manubrium or to the left of it. The arch is in close contact behind with the trachea, esophagus, thoracic duct, and left recurrent nerve, which latter winds around it (Fig. 69). All of these may be compressed by an aneurism or it can burst into the trachea or esophagus, causing fatal hemorrhage. The orifice of one of the large branches of the arch of the aorta may be closed by atheroma, causing a disappearance of the pulse in the corresponding peripheral vessel, *e. g.*, radial artery.

**Vena Cava Superior.**

The vena cava superior (Fig. 53) begins opposite the second and third right costal cartilages, lying behind and to the right of the aorta. Before entering the pericardium, it receives the vena azygos (Fig. 58). This latter vessel lies to the right of the spinal column in the posterior mediastinum. On the left side there is a similar but smaller vein (hemiazygos vein). They communicate with the lumbar veins (branches of the vena cava inferior), and in cases of obstruction of the latter (tumors of the abdomen) provide for a collateral circulation between the inferior and the superior venæ cavæ.

**Vena Cava Inferior** (see Fig. 53).

Passes from its opening in the diaphragm to the right auricle. Two-thirds of its length lies inside of the pericardial cavity.

**Thoracic Duct** (Fig. 58).

The thoracic duct begins in the abdominal cavity, opposite the second lumbar vertebra. It passes through the diaphragm with the aorta, then upward through the thorax between the azygos vein on the right, the aorta on the left, and the esophagus in front (Figs. 54 and 55). At the level of the fifth dorsal vertebra it crosses to the left of the median line and ascends to empty into the left subclavian vein close to its junction with the internal jugular. Its relations in the neck have been described above. Its highest point is the left transverse process of the sixth cervical vertebra, lying in front of the vertebral artery here.

**Phrenic Nerves** (Figs. 41, 43, and 55).

These are the chief motor nerves of the diaphragm. In the neck they lie in front of the scalenus anticus on each side, and pass down in front of the subclavian artery into the thorax. In the thorax they lie between the pericardial pleura and pericardium. The left passes to

the left of the median line in front of the aorta and root of the lung, to make room for the heart. The right is shorter, passes on the right side of the right innominate vein, and vena cava superior, to the diaphragm—lying external to the pericardium, as on the left side.

**Thoracic Portion of Vagus** (Figs. 54, 55, and 69).

The right vagus passes from the neck, where it lies in front of the subclavian artery, into the thorax, lying in the latter at first between the right innominate and azygos veins and trachea, then close to the esophagus, gradually passing behind and through the diaphragm with it. The left differs from the right in lying in front of the arch of the aorta, giving off the recurrent laryngeal here (hence compressed here by aneurisms).

**Pleuræ.**

At the upper end of the thoracic cavity the parietal pleura projects one and one-half inches through the superior aperture of the thorax, being attached firmly to the vertebral column, and forming the apex of the pleural cavity. This portion is in close relation with the subclavian artery and brachial plexus on each side of the neck, and with the thoracic duct, in addition, on the left side (Figs. 31, 41, and 49). At the lower end of the pleural cavity (or space between the parietal and visceral pleura), where the parietal is reflected on the upper surface of the diaphragmatic pleura, there is a small space, the complementary or sinus pleuræ, sometimes called the costophrenic sinus (Fig. 67), which is empty, except during deep inspiration; it contains normally a few drops of fluid. In this sinus pleuritic effusions first collect, so that on the surface of the body the normal markings of the lower limits of the lung are raised and the inspiratory descent of the lower border of the lung is absent. This sinus is also obliterated in tumors, etc., of the abdomen, which push the diaphragm upward. The parietal and visceral pleuræ are in such intimate contact with each other normally that there is no pleural cavity. Such a space is only present when the lung is pushed toward the vertebral column by a collection of fluid (hydrothorax, serothorax, hemothorax, pyothorax), or air (pneumothorax), or after death owing to the collapse of the lung (Figs. 54 and 55). On account of the close proximity of the two pleural layers, an inflammation of the visceral will be immediately referred to a corresponding point of the parietal. Similarly, an inflammation of that portion of the visceral layer covering the inferior surface of the lung is often referred to the abdomen, especially in children (diaphragmatic pleurisy) and may sim-

ulate an abdominal affection. At the junction of the pleura and diaphragm the pleura is reflected over the surface of the diaphragm, then again along the mediastinum as far as the root of the lung, becoming here the mediastinal pleura. The relations of the pleuræ are best seen in a cross-section at the level of the ninth dorsal vertebra—*i. e.*, the fourth rib in front (Fig. 55). The two mediastinal pleuræ meet behind the sternum, then separate to inclose the pericardium, extending as far back as the root of the lungs. From the point of attachment of the mediastinal pleura to the root of the lung it is reflected upon the mesial surface of the lungs as the visceral pleura. The latter then continues as the covering of the lung (on both sides), dipping into the interlobar fissures, and lining them with pleura. At the posterior surface of the lung it dips in again as far as the root of the lung, being reflected upon itself. Its continuation covers the lateral aspect of the esophagus and aorta, forming the posterior mediastinal pleura again. At the points of attachment to the sternum in front and vertebræ behind, the mediastinal pleura is reflected on either side upon the inner aspect of the thorax as the parietal or sternocostal pleura. The latter is seen to cover the interior of the thorax, being attached to the inner surface of the ribs, except where the pericardium is attached.

The pleuræ may at times extend beyond the level of the last rib in front of the lumbar vertebræ, and may thus be opened in operations upon the kidney (see Abdomen). This is especially true when the twelfth rib is quite short (Fig. 69).

**The Trachea** (see Fig. 53).

The trachea begins at the sixth cervical (below cricoid cartilage), and ends at the fourth dorsal vertebra (Fig. 69) (level of second ribs or at junction of first and second portions of sternum). Behind the sternum, lying in front of the trachea, are the left innominate vein, the thymus (in children) (Figs. 37 and 71), and the innominate artery (Figs. 53 and 56). The left common carotid lies to the left of the trachea. A little lower down the trachea is crossed by the arch of the aorta and pulmonary artery. Behind it lies the esophagus (see Fig. 54). Aneurisms of the arch of the aorta frequently press upon the trachea, causing intense dyspnea. The trachea divides into two main bronchi behind the pulmonary artery. At its point of bifurcation the trachea is surrounded by a number of lymph-nodes (bronchial), which may press upon it when diseased, or rupture into it when they are the seat of a tubercular process. A primary carcinoma arising from these nodes may compress the trachea. The **right and left main bronchi** take

an arched course; the left is longer, and hence the more frequent lodging-point of foreign bodies. The left bronchus lies in front of the aorta, the artery arching over it to reach the vertebræ (see Figs. 53, 54, and 69). Hence it is often compressed by aneurisms of the aorta. The esophagus lies behind the trachea in its entire course (Figs. 33, 41, and 54). The main bronchi give off ventral and dorsal branches. They are supplied by branches of the aorta (bronchial arteries), which also nourish the lungs and anastomose with the branches of the pulmonary artery, so that in case of obstruction in the latter a collateral circulation can develop.

**Lungs** (see Figs. 49 and 55).

The right is divided into three, the left into two, lobes. Their relations to the surface have been given above. They have an outer convex surface, lying in close apposition with the parietal pleura; hence, the lung is often injured in fractures of the ribs, etc., giving rise to traumatic pneumonia. The inner or medial surface is concave, to inclose the heart.

A depression in this surface, known as the hilum, is the point of entrance of the pulmonary artery and vein, of the bronchi, bronchial arteries, veins, and lymph-vessels. These structures, all intimately bound together by connective tissue, are known as the root of the lung. The lower surface or base fits the convexity of the diaphragm closely (Fig. 47). On the right side the base is formed by the lower and the middle lobe; on the left side by the lower lobe only (Fig. 49). On the right side the lobes are separated from the liver only by the diaphragm. For this reason right-sided subphrenic or hepatic abscess is liable to rupture into the right lung (see Figs. 47, 49, and 67). The apex of each lung (relations given above) projects one and one-half inches above the clavicle. It has no complementary space, and is the least expansible of any portion of the lung. The lower border of the left upper lobe has some degree of respiratory excursion over the upper border of the heart. Use of this fact is often made in determining the upper border of cardiac dulness.

In adults the lungs are of a grayish color; in children, reddish. In the former they are streaked with black, outlining the alveoli (coal pigment). The respiratory circulation of the lungs is carried on by the pulmonary artery and vein, forming a capillary network in each alveolus. The nutrition is provided for by the bronchial arteries. The lymphatics form a rich network around each alveolus, and return the lymph to the bronchial glands at the root of the lung. Seventy-

five per cent. of all metastatic abscesses in pyemia occur in the lungs, on account of the fine capillary network arresting the emboli. Wounds of the lungs, unless they involve a large vessel, are not fatal, as a rule. If there is a wound of the lung, air often escapes, producing pneumothorax; and if, at the same time, there is a wound of the parietes, there is subcutaneous emphysema. Pneumonia may either affect a few lobules around a bronchus (bronchopneumonia), an entire lobe or a lung (lobar pneumonia). When the lung is displaced by a pleuritic effusion, it always collapses toward the root. If pressure is not relieved, the condition of collapse may become permanent (atelectasis).

## The Mediastinum.

The mediastinum is the space between the two layers of mediastinal pleura (see Figs. 54 and 55). It has an anterior portion lying in front of the roots of the lungs, and a posterior behind them, the two being directly continuous. The anterior contains the thymus gland above (Figs. 37 and 71), which develops during the last months of fetal life, and persists as a bi-lobed pale-red structure until the age of puberty. It lies behind the first portion of the sternum, in front of the innominate vein (left) and trachea. In rare cases it may compress the latter, causing asphyxia. Below, the anterior portion of the mediastinum contains the heart and beginning of the large vessels. It is connected with the space between the outer and middle (previsceral) layers of the deep cervical fascia, and abscesses between these are liable to drain into it (from cervical glands, etc.).

The posterior portion of the mediastinum lies behind the pericardium. It contains the esophagus, to each side of which are the vagi, descending aorta, azygos vein, and thoracic duct (Figs. 46 and 49). The posterior portion of the mediastinum communicates with the prevertebral space in neck (Fig. 35). The entire mediastinum is occasionally the seat of sarcomata, causing marked pressure symptoms (varicose veins of skin of thorax) and dyspnea. An obstruction of the venæ cavæ as the result of such a tumor is relieved (Fig. 57) through a collateral circulation established through the intercostal veins with the azygos and subclavian (through internal mammary) veins.

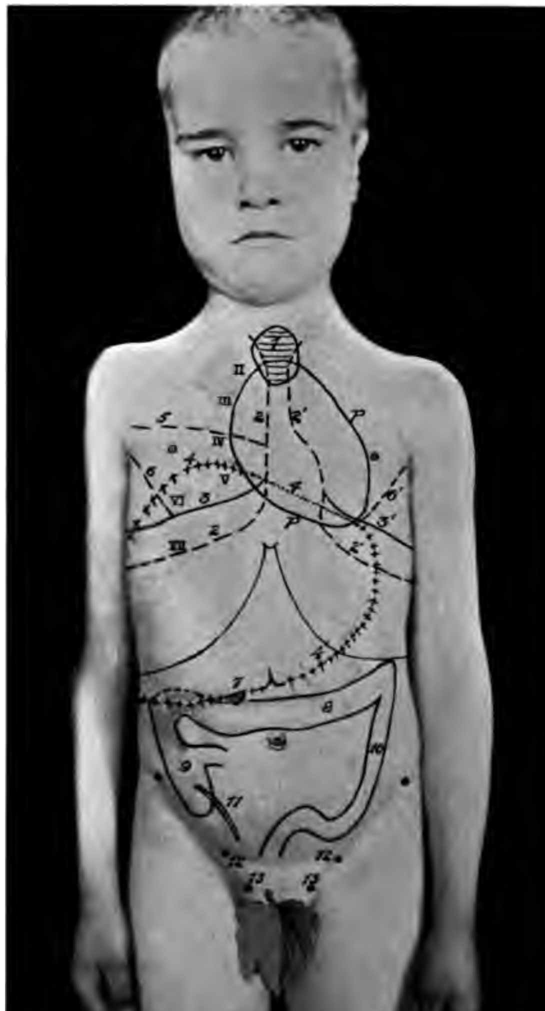

Fig. 71.—Relations of abdominal and thoracic viscera in a child of seven years. 1, Thymus gland. 2, Outline of right pleura. 2′, Left pleura. 3, Lower border of right lung. 3′, Lower border of left lung. 4, Upper border of liver. Note the large size of the liver in the child. 4′, Lower border of liver. 5, Interlobar fissure between right upper and right middle lobes. 6, Interlobar fissure between right middle and right lower lobes. 6′, Fissure between left upper and left lower lobes. 7, Gall-bladder. 8, Transverse colon. 9, Ascending colon and cecum (observe the relatively large size of cecum). 10, Descending colon. 11, Appendix. 12, Internal abdominal ring. 13, External abdominal ring. P, Pericardium.

# THE ABDOMEN.

THE abdomen has, as its external limits, the costal arches, folds of the groin (inguinal), and crests of the ilia. These do not correspond to the internal limits, which are the diaphragm above and the outlet of the pelvis below. It has a bony support along its median line behind (vertebral column) and along the upper and lower portions of its lateral walls in the form of the lower ribs and walls of the pelvis, but has no bony support in front and for that portion of its sides which lies between the last rib and the crest of the ilium. Hence, these parts can adapt themselves to changes in form readily. This is especially true of the anterior abdominal wall. The abdominal walls are so elastic that a blow—for example, a kick, or a fall upon some blunt object—or a crushing force may cause no injury to the surface and still produce serious laceration of the viscera, solid and hollow. Of 292 cases of abdominal contusion without any external signs, collected by Makins, nearly one-third showed ruptures of the viscera.

The **degree of prominence or retraction of the abdomen** depends normally: (1) upon the amount of distention of the hollow viscera; (2) upon the size of the solid viscera, such as the liver, spleen, etc.; and (3) upon the amount of fat in the subcutaneous tissue and omentum. In children the disproportionately large size of the liver, and the fact that the pelvis is quite small and can hold but few of the intestinal coils, causes the abdomen to be especially prominent (see Figs. 25 and 71). Under pathologic conditions the abdomen becomes more prominent when there is a collection of free or encapsulated fluid, when tumors are present, or when there is excessive distention of the intestine (tympanites) from any cause. Retraction of the abdomen is a symptom of lead colic, of tubercular meningitis, or of great emaciation.

**Examination of the Abdomen in the Living.**—1. Note the linea alba, which is indicated by a slight median groove above the umbilicus, and below the same by a line of hair or deposit of brownish pigment frequently descending from the umbilicus to the symphysis pubis.

2. In muscular individuals note the slight transverse depressions in the course of the recti muscles. These are the lineæ transversæ (see Fig. 75), which interrupt the rectus at various points in its course, the one opposite the umbilicus being especially marked. Some individuals have the ability to cause the intervening portions of muscle to stand out prominently and thus resemble tumors.

3. Note the linea semilunaris, which corresponds to the point of

junction of the aponeuroses of the muscles of the anterior abdominal wall. It is represented by a slightly curved line from the tip of the ninth costal cartilage to the pubic spine. Above the umbilicus it is represented by a shallow depression.

4. Examine the umbilicus. This is readily seen, except in very stout persons. It corresponds behind to the disc between the third and fourth lumbar vertebræ. Not infrequently, there is a mass of fat between the fibrous portion, or umbilical ring, and the skin.

5. Palpate the anterior and posterior superior spines of the ilium, which can be readily felt except in very stout people. The first-named forms the outer limit of Poupart's ligament and is used as a fixed point in many measurements of the lower limb (see Fig. 134). Between the two spines on either side can be felt the crest of the ilium.

6. Palpate Poupart's ligament. It is a firm band which can be felt extending from the anterior superior spine to a bony prominence upon the upper surface of the symphysis pubis, just external to the outer border of the rectus. This bony point is the pubic spine. (See Figs. 72 and 75).

7. The pubic spine can be best felt by invaginating the scrotum with the index-finger passed along the spermatic cord in the male, and in the female by adducting the thigh and thus making prominent the tendon of origin of the adductor longus muscle.

8. By the same procedure the external abdominal ring can be felt, both in the male and female, admitting the tip of the index-finger, in the adult, and the tip of the little finger in children, under normal conditions, although one occasionally meets with individuals in whom the external abdominal ring will easily admit two fingers under normal conditions.

9. Over the back of the abdominal region, especially when the patient stands erect, can be felt the masses of the erector spinæ muscles, and in the groove between them, the spines of the lumbar vertebræ (see chapter on Spine).

10. Palpate the ensiform process and the costal cartilages of the ribs which form the costal arches. Mark with a pencil the tips of the seventh, eighth, ninth, and tenth costal cartilages, and also the free ends of the eleventh and twelfth ribs, which can be palpated in lean individuals by inserting the tips of the fingers just above the crests of the ilia.

## Surface Markings.

1. The **abdominal aorta** corresponds to a line drawn from a point


Fig. 72.—Surface markings of kidneys, ureters, and vessels of abdomen. 1, Vena cava inferior. 2, Aorta. The celiac axis is shown just below the figure 2. 3 and 4, Right and left renal veins. 5 and 6, Right and left renal arteries. 7 and 8, Right and left ureter. 9, Left spermatic vein, emptying into left renal vein. 10, Right spermatic vein, emptying into vena cava inferior. 11, Superior mesenteric artery. 12 and 13, Right and left spermatic arteries. 14, External iliac arteries. 15, External iliac veins. R.K., Right kidney. L.K., Left kidney. S.P., Spleen.

a little to the left of the ensiform process to a second point three-fourths of an inch below the umbilicus and also to the left of the middle line. The point at which the celiac axis is given off from the aorta is four or five inches above the umbilicus. The renal arteries are given off at a point three and a half inches above the umbilicus. (See Figs. 72 and 80.)

2. The **common and external iliac arteries** correspond to a line from the point of termination of the aorta (three-fourths of an inch below and a little to the left of the umbilicus) to a point midway between the anterior superior spine of the ilium and the pubic symphysis. The upper third of this line corresponds to the common iliac (Fig. 60), the lower two-thirds to the external iliac.

3. The **deep epigastric artery** corresponds to a line from the middle of Poupart's ligament to the umbilicus (see Fig. 79).

4. The **inferior vena cava and common and external iliac veins** correspond to the lines given above for the aorta and the iliac arteries respectively, but lie a little to the right of the same (Figs. 72 and 80).

### Divisions of Abdomen.

Before proceeding to give the surface markings for the superficial and more deeply situated abdominal viscera, it will be necessary to recall that the abdomen is arbitrarily divided into nine regions, by two vertical and two horizontal lines. The vertical ones are drawn on each side through Poupart's ligament at a point midway between the anterior superior spine of the ilium and the median line at the upper border of the symphysis pubis. The two horizontal lines are, one drawn through the two anterior superior spines of the ilia, and another at the level of the lowest part of the tenth costal cartilages (Fig. 49).

The subdivisions of the upper zone, from right to left, are the **right hypochondriac,** the **epigastric,** and the **left hypochondriac** regions. Those of the middle zone, from right to left, the **right lumbar,** the **umbilical,** and the **left lumbar** regions. Of the lower zone, the **right iliac,** the **hypogastric,** and the **left iliac** regions.

The relations of the various organs of the abdomen to the surface are the following:

The **liver** lies in the right hypochondriac and epigastric regions. Its upper border, apex of convexity of right lobe, extends as high as the right fourth interspace (see Fig. 68) in the mammary line. This upper marking is, however, at a deep level; in reality, on the surface the upper border of the liver is at the lower border of the sixth rib in the mammary

line, the lower border of the eighth rib in the mid-axillary line, and at the lower border of the tenth rib in the scapular line. Its lower margin corresponds superficially to the eighth rib in the axillary line, tenth dorsal vertebra behind (see Fig. 69), and in front to a line drawn from the tip of the ninth right costal cartilage to the eighth left costal cartilage. At a deep level it extends to the eighth rib (right) behind. The left border of the left lobe of the liver extends as far as the left parasternal line (Fig. 68).

5. The **gall-bladder** is at the angle between the ninth costal cartilage and the outer border of the right rectus.

6. The **stomach** lies in the epigastric and left hypochondriac regions. Its upper border (lesser curvature) is overlapped by the lower margin of the liver (see Fig. 68). Its lower border or greater curvature crosses behind the left costal arch opposite the tip of the ninth costal cartilage, and extends as far downward as a distance of about two finger-breadths above the umbilicus (two inches). The pylorus lies, as a rule, about one inch to the right of the middle line. When the stomach is empty, the pylorus generally lies in the middle line. When distended, it may reach two or even three inches to the right of the middle line. The pyloric portion of the stomach is practically bisected by a horizontal plane which passes through the abdomen midway between the suprasternal notch and pubic symphysis (Addison). The fundus of the stomach lies under the left dome of the diaphragm (see Figs. 68 and 69). The cardiac orifice corresponds to a point over the left seventh costal cartilage, one inch from the sternum.

7. **Small Intestines.**—The duodenum corresponds on the surface (see Figs. 73 and 74) to the right half of the epigastric region behind the eighth costal cartilage (horizontal portion); the second or vertical portion lies midway between the median line of the body and the vertical line which separates the right hypochondriac from the epigastric regions. The third or ascending portion passes obliquely upward across the body from the right half of the umbilical region to the left half of the same, where it joins with the jejunum at a point one inch to the right of the median line (duodeno-jejunal flexure), at a point about midway between the ensiform process and umbilicus (Figs. 68, 69, 73, and 74).

The small intestines lie, as it were, within a frame formed by the large intestine (see Fig. 68). They overlap the ascending and descending colon respectively and extend downward into the pelvis. The portions which come in contact with the anterior abdominal wall (being separated from it by the omentum) are to some extent the jejunum, but chiefly the ileum.

8. **Large Intestine.**—The surface markings of the cecum correspond to the right iliac and hypogastric regions, just below a line drawn from the anterior superior spine to the umbilicus, the ileocecal valve being situated at a point one inch below the mid-point of this line. The appendix lies in the right iliac and hypogastric regions, in its typical position hanging down over the brim of the pelvis (see Fig. 68). Its base or orifice corresponds approximately to a point two inches below the mid-point of the line drawn from the anterior superior iliac spine to the umbilicus. The most frequent point (McBurney's) at which pain is felt in the appendiceal inflammations is midway in this line, which does not correspond exactly anatomically to the position of the appendix. The ascending colon extends vertically upward in the right lumbar and right hypochondriac regions, as high as the tenth costal cartilage (hepatic flexure), lying immediately to the right of the gall-bladder. The transverse colon crosses the upper part of the umbilical region, ascending obliquely from the left lumbar to the left hypochondriac region (see Figs. 51, 52, 68, and 69) as far as the lower extremity of the spleen (splenic flexure). The descending colon passes vertically downward in the left lumbar and iliac regions, passing over into the iliac colon (sigmoid flexure) in the hypogastric region (see Fig. 68).

9. **The Pancreas.**—This lies immediately below the stomach at a deep level, occupying the curve of the duodenum at the lowest portion of the epigastric region (head of pancreas) and crossing this region obliquely upward to the left, as far as the left hypochondriac region (the tail) (Figs. 49, 69, 73, and 74).

10. The **spleen** extends as far forward as the costo-clavicular line (line from inner end of clavicle to tip of tenth costal cartilage), occasionally to the mid-axillary line (see Figs. 51, 69, and 74), and from the ninth to the eleventh ribs.

11. The surface markings of the **kidneys** on the anterior surface of the abdomen are as follows: The upper borders extend as high in the epigastric region as a line drawn about two inches below the ensiform or xiphoid process. The right always lies lower than the left. The lowest point of the kidney reaches down as far as a line drawn between the lower borders of the curves of the tenth costal cartilages (Figs. 72 and 74). Posteriorly, the kidneys extend on the surface of the body from the eleventh rib to the level of the third lumbar spine, the left kidney lying about one-half inch higher than the right, the outer border extending about four inches from the median line of the back (Figs. 69 and 50). The **ureters** correspond on the anterior surface of the body to a line drawn almost vertically in the umbilical region from the hilus

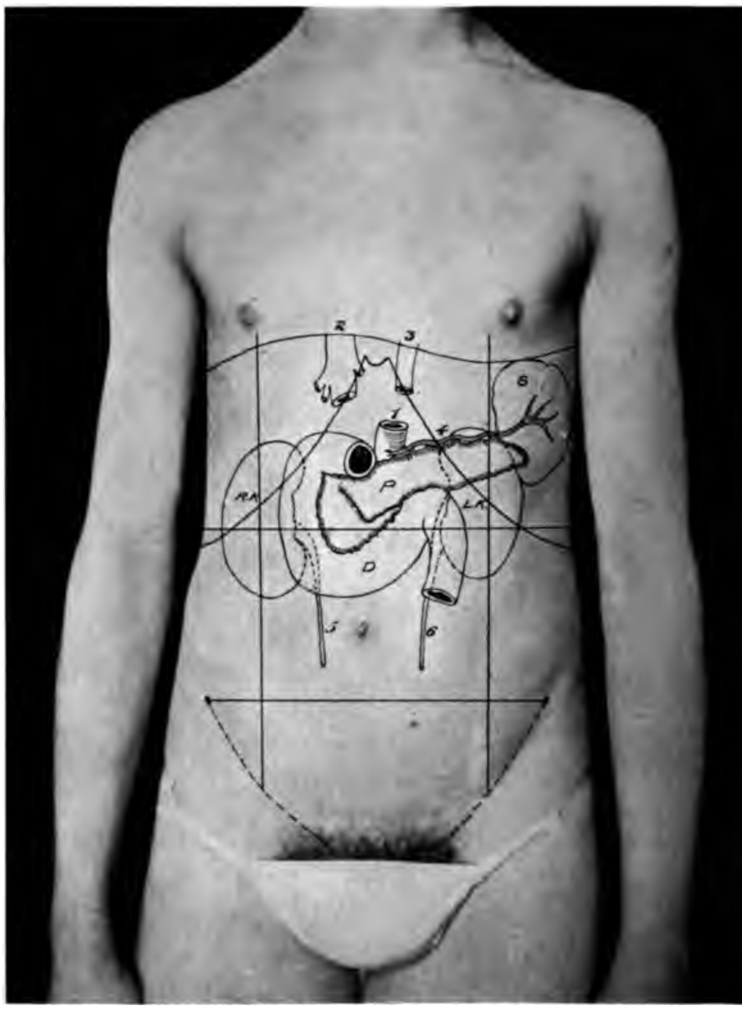


Fig. 74.—Relations of duodenum, pancreas, kidneys, and spleen. 1, Aorta. 2, Vena cava inferior. 3, Esophagus. 4, Splenic artery. 5, Right ureter. 6, Left ureter. R.K., Right kidney. L.K., Left kidney. D, Duodenum. P, Pancreas. S, Spleen.

at the crest of the ilium. In the interval between the symphysis and the pubic spine—*i. e.*, around the external abdominal ring—it has no attachment, but is continuous with the deep fascia of the scrotum (dartos). Extravasated urine can escape to the surface of the abdomen through this interval, but will be limited by the attachments of the deep layer of fascia to Poupart's ligament, from escaping to the thigh. Between the two layers of the superficial fascia lie the vessels, nerves, and lymphatics which supply the skin of the abdomen.

The **vessels** are the superficial epigastric, the superficial circumflex iliac and the superficial external pudic arteries and veins (branches of the femoral artery and vein) in the lower half, and the anterior and posterior intercostals above (branches of internal mammary and thoracic aorta) (see Fig. 57). In cases of obstruction in the portal or abdominal circulation (*e. g.*, cirrhosis of the liver, aneurisms of aorta, etc.) these vessels assist the deeper ones of the abdominal wall (see below) in establishing a collateral circulation. The superficial **lymphatics** of the skin of the upper half empty into the axillary, those of the lower half into the inguinal glands (see Figs. 59 and 60).

### The Abdominal Walls.

The anterior abdominal walls vary greatly in thickness. This variation is dependent, first, upon the amount of subcutaneous fat, and, second, upon the development of the abdominal muscles. They may be so thin, especially in children, that the contours of the hollow viscera may be seen through them, and this fact is often used to observe the so-called "peristaltic wave." In cases of pyloric or intestinal obstruction a visible wave of this kind, traveling in an opposite direction to the normal one, is of great diagnostic value. It indicates a stenosis or narrowing of the lumen, and is called an antiperistaltic wave.

The chief **muscles** of the anterior abdominal walls are the external and internal oblique, transversalis, and rectus on each side. The **external oblique** arises chiefly from the eight lower ribs and crest of ilium; its fibers run downward and inward, ending in a broad aponeurosis which passes across the front of the rectus to the median line, assisting the aponeurosis of the internal oblique in forming its anterior sheath (see Figs. 75 and 84). The lower portion forms the greater part of Poupart's ligament, and divides opposite the pubic spine to form the external abdominal ring (Fig. 75), the portion attached to the pubic spine being called the inner pillar, that attached to the horizontal ramus the outer pillar. The fibers arching across the ring between the two pillars are called the intercolumnar fibers or external spermatic fascia.

**The Internal Oblique.**—Arises from the three lower ribs, crest of the ilium, and the outer half of Poupart's ligament; its fibers run upward and inward, and terminate in an aponeurosis which divides at the outer border of the rectus (linea semilunaris) into an anterior layer, which unites with the aponeurosis of the external oblique to form the anterior half of the sheath of the rectus, and a posterior layer which passes behind the rectus to form its posterior half (see Figs. 75 and 83). Midway between the umbilicus and symphysis pubis (see Fig. 76) both layers of the internal oblique gradually pass in front of the rectus, so that it is separated from the peritoneum here by the transversalis fascia only. The lower fibers of the internal oblique are continued over the spermatic cord as the cremaster muscle (Fig. 77). The fibers of the internal oblique which arise from Poupart's ligament unite with those of the transversalis, forming the conjoined tendon to be inserted into the crest and spine of the pubes in front of the rectus.

**The Transversalis.**—Arises from the inner surface of the lower six costal cartilages, from the crest of the ilium, and outer third of Poupart's ligament, and from the anterior or inner lamella of the lumbar fascia (Fig. 86). Its fibers pass transversely across the median line, ending in a broad aponeurosis which passes behind the rectus in its upper two-thirds; but midway between the umbilicus and pubis it passes in front of it with the external and internal oblique. Its inner surface is covered by the transversalis fascia, which separates the muscle from the parietal peritoneum, being very thin above, but very strong below the umbilicus. It joins with the internal oblique to form the conjoined tendon (Figs. 76 and 88).

**The Rectus.**—Arises from the ensiform process and fifth, sixth, and seventh costal cartilages; its fibers pass directly downward to be inserted into the upper surface of the symphysis pubis. Its sheath is formed by the other abdominal muscles, as given above; namely, in its upper three-fourths by the external oblique and anterior layer of the internal oblique aponeurosis in front and the posterior layer of the internal oblique and transversalis behind (Fig. 83). In the lower one-fourth of the linea alba the sheath is very strong in front, having the aponeuroses of all three muscles (external and internal oblique and transversalis), but comparatively weak behind, consisting only of the transversalis fascia and peritoneum (see Fig. 88).

**The Transversalis Fascia.**—This layer above the umbilicus is scarcely of sufficient thickness to be called a membrane; below the navel it becomes quite thick and firm, forming an aponeurosis which serves as a posterior covering to the rectus, and takes the place there of the internal

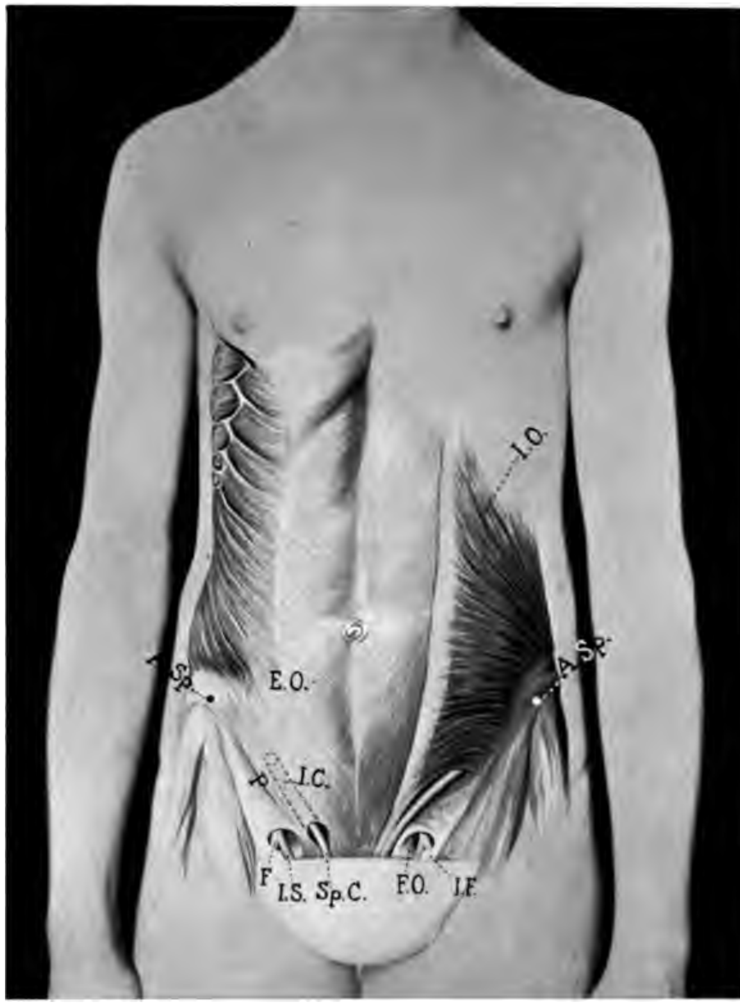


Fig. 75.—Topography of inguinal and femoral hernial regions (superficial layers) A.Sp., Anterior superior spine of ilium. I.C., Inguinal canal, shown in dotted outline. At its lower end (external abdominal ring) the spermatic cord is seen to emerge. At its upper end, corresponding to the dotted circle, is situated the internal abdominal ring (a little above the middle of Poupart's ligament). E.O., External oblique muscle, the aponeurosis of which divides to form the external abdominal ring. I.O., Internal oblique muscle, showing its attachment to outer half of Poupart's ligament; toward the median line its aponeurosis is shown, uniting with that of the external oblique. F, Femoral vein. P, Poupart's ligament. I.S., Internal saphenous vein. F.O., Fossa ovalis, covered by cribriform fascia. I.F., Outer layer of iliac fascia forming the falciform border.

oblique. Between the external and internal oblique and transversalis muscles there is loose connective tissue, favoring the spread of abscesses and extravasations of blood between them. The abdominal muscles are powerful expiratory muscles, and exert a positive pressure upon the abdominal contents during expiration; hence, stab wounds are irregular and gape during inspiration. For the same reason it is difficult to secure rest for the wounds of the abdominal wall, and there is a greater disposition to the formation of herniæ after operations.

**The Linea Alba.**

This corresponds to the point of union of the abdominal muscles in the median line (see Fig. 76). It is widest just above the umbilicus, being eighteen to twenty millimeters here; while below the same it gradually decreases, being only two millimeters wide above the symphysis pubis. It is widened during pregnancy or when an abdominal tumor is present, causing diastasis or separation of the recti muscles, so that the hand can often be placed between the recti. It has many openings for blood-vessels and nerves; these may become enlarged and favor the formation of a hernia. Such herniæ of the linea alba must not be confounded with lipomata, which can occur in the median line, and which may give rise to symptoms like those of a hernia, even of incarceration. The **parietal peritoneum** is firmly adherent to the linea alba and umbilicus; lateral to it, it has considerable subserous fat.

**Deep Arteries of the Abdominal Wall.**

In the upper portion of the abdominal wall these are derived from the last intercostals and lumbar arteries; in the lower portion from the deep epigastric branch of the external iliac artery. The latter is of considerable importance in the surgical anatomy of hernia; it lies beneath the transversalis fascia just above Poupart's ligament (Figs. 75, 76, and 79) and then penetrates the sheath of the rectus muscle. Its course can be described as corresponding to a line drawn from the middle of Poupart's ligament to the umbilicus. It anastomoses with the deep superior epigastric branch of the internal mammary.

**The Veins of the Abdominal Wall.**

The superficial as well as the deep veins anastomose freely; those supplying the lower half of the abdominal wall anastomose freely with those of the upper half, and also with the vein which runs in the ligamentum teres or suspensory ligament of the liver into the portal vein. Thus a collateral circulation is easily formed in cases of obstruction to

either the vena cava or the portal circulation. There may be such a radiation of veins at times from the umbilicus as to give rise to the appearance of what has been called the caput medusæ (see Fig. 57). In the Talma-Morrison operation advantage is taken of this fact to establish a collateral circulation between the omentum and abdominal wall to relieve the ascites of cirrhosis of the liver.

**The Nerves.**

The abdominal muscles as well as the skin of the abdominal wall are supplied by the last six intercostals and the first lumbar nerve. This is of considerable clinical importance, because any irritation of the skin will produce a reflex contraction of the abdominal muscles. These nerves also anastomose freely with the branches of the sympathetic plexus (Fig. 104), so that a blow upon the abdominal wall will not infrequently cause a paralysis of the blood-vessels supplied by the solar plexus, resulting at times in fatal syncope. Pleuritic pain, especially if the pleurisy is situated close to the diaphragm (diaphragmatic pleurisy), is often referred along the intercostal nerves to the abdomen, and, similarly, pressure upon the intercostal and lumbar nerves, due to tuberculosis or tumors of the spine or spinal cord, will be referred to the ends of the nerves in the abdominal wall.

The nerves of the skin of the trunk have still more important associations. The spinal segments with which they are connected are also in communication with the viscera of the abdomen and thorax through the sympathetic system (see Figs. 23 and 80). Hence, diseased conditions of the abdominal viscera give rise to disturbances in the spinal segments with which they are connected, and the brain, being accustomed to localize pain along the spinal nerves, makes a mistake and refers the pain along the spinal nerve of the segment disturbed. Not only is pain referred, but the skin supplied by the disturbed spinal segments becomes tender, and through a study of these, Head has been able to localize the visceral centers, thus affording the surgeon a means for increased accuracy of location of pain as a symptom in abdominal diagnosis.

The abdominal viscera are supplied from the sixth dorsal to the first lumbar segments of the spinal cord, the nerves passing to their destinations through the rami communicantes, splanchnic nerves, and sympathetic plexuses of the abdomen (see Figs. 23, 80, and 104). No visceral nerves escape through the second, third, or fourth lumbar nerves, hence these are never the seats of visceral referred pains. The pelvic viscera are supplied from the fifth lumbar to the third or sometimes fourth sacral nerve through the nervi erigentes.

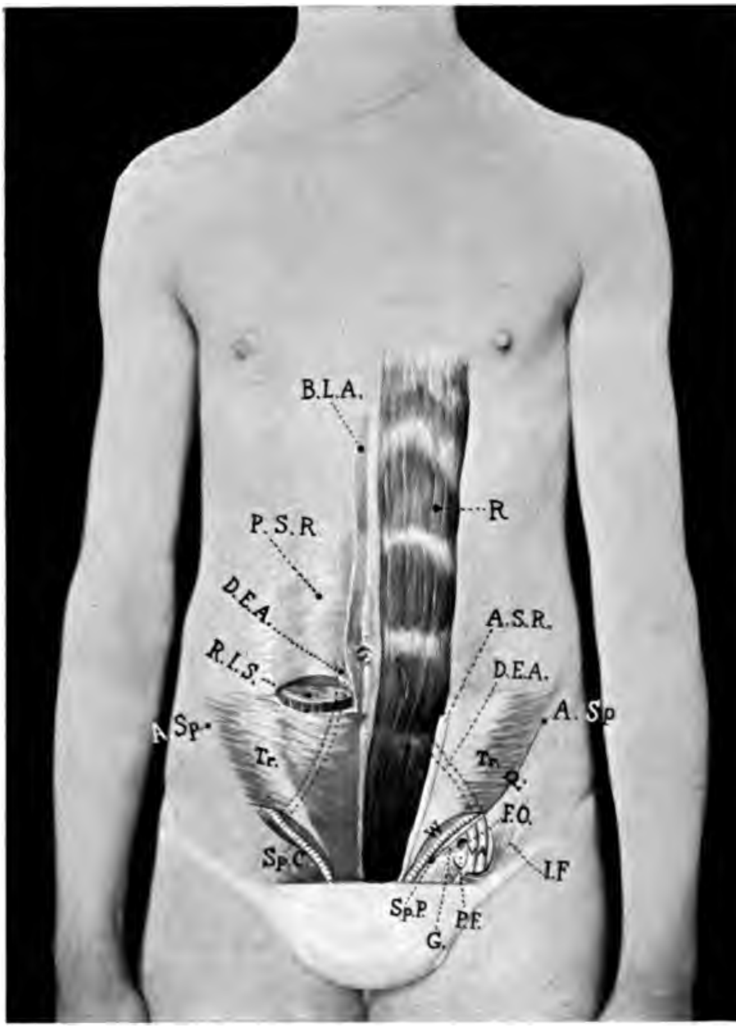


Fig. 76.—Topography of inguinal and femoral hernia (deeper layers). Sp.C., Spermatic cord, in inguinal canal, lying upon Poupart's ligament. Tr., Transversalis muscle, attached to outer half of Poupart's ligament, and joining with internal oblique to form the conjoined tendon (W), which passes in front of the rectus to be attached to upper border of pubis. A.S.R., Anterior half of sheath of rectus turned back, formed below by aponeurosis of external oblique and conjoined tendon. P., Poupart's ligament. D.E.A., Deep epigastric artery, shown in outline. It lies between the transversalis fascia and peritoneum. A.Sp., Anterior superior spine of ilium. R.I.S., Right rectus, cut transversely, showing anterior and posterior halves of sheath (P.S.R.). B.L.A., Linea alba, broad above umbilicus, but narrowing gradually toward pubis. R., Left rectus, showing tendinous portions, most marked above umbilicus. Sp.P., Spine of pubis. An inguinal hernia emerges to the inner side of it; a femoral to outer side of it. G., Gimbernat's ligament. F.O., Femoral opening. I.F., Iliac fascia (outer layer), with its falciform border, across the lower edge of which the internal saphenous vein (P.F.) crosses to enter the femoral vein (V.). A., Femoral artery.

The following are the segments with which each viscus is connected (Figs. 23 and 80):

| Viscus. | Spinal Segment. | Area. | Maximum Points. |
|---|---|---|---|
| Esophagus, cardiac end. .... | Sixth Dorsal. | Infrascapulo-mammary. | Anterior: fifth rib, one inch internal to nipple line.<br>Posterior: seventh spine, one and one-half inches from mid-line. |
| Stomach. ....... | Seventh, Eighth, and Ninth Dorsal. | Subscapulo-ensiform. | Anterior: over ensiform cartilage.<br>Posterior: ninth spine, from this to scapular angle. |
| Liver. ......... | Eighth and Ninth Dorsal. | Middle epigastric. | Anterior: eighth space, two inches outside nipple-line.<br>Posterior: one and one-half to two and one-half inches below angle of scapula, and two to three inches outside of mid-line. |
| Gall-bladder ... | Ninth Dorsal. | Supra-umbilical. | Anterior: tip of tenth costal cartilage.<br>Posterior: eleventh dorsal spine, one and one-half inches from mid-line. |
| Kidney ........ | Tenth and Eleventh Dorsal. | Subumbilical. | Anterior: one and one-half inches outside and one inch below umbilicus.<br>Posterior: tip of twelfth rib. |
| Uterus ........ | Eleventh Dorsal. | Gluteo-crural. | Close to great trochanter.<br>Above, and on inner side of knee. |
| Fallopian tubes. | Eleventh Dorsal. | Sacro-iliac. | Anterior: above Poupart's ligament, at level of internal ring.<br>Posterior: fifth lumbar and first sacral spine. |
| Bladder and prostate. ..... | Eleventh Dorsal. | Sacral area. | Anterior: tip of glans penis.<br>Posterior: over ischial tuberosity; over lower sacrum. |

Pain referred to areas supplied by the lower abdominal nerves in connection with spinal caries may mislead the surgeon as to the real seat of the malady, and arouse a suspicion of mischief in the kidneys or bladder. Pott's disease is often referred to the terminal portions of the nerve, especially over the front of the abdomen.

## Abdominal Incisions.

The line of incision for laparotomy is most frequently made in the median line along the linea alba, some operators preferring to divide exactly through the latter, and others laterally to it, through the sheath of the rectus, either right or left side. The peritoneum is quite firmly adherent to the linea alba, so that great care must be exercised in suturing

a wound in the median line lest the peritoneum prolapse, the edges of the recti pull apart, and a post-operative ventral hernia result. This can be avoided to a great extent by bearing in mind the anatomic relations.

The peritoneal edges will usually approximate without much traction, but it is very difficult to avoid a hernia unless care is taken, in that portion of the linea alba which lies above the junction of its lower and middle thirds, to remember that the anterior and posterior halves of the sheath of the rectus are of about equal strength and both should be pulled well forward toward the median line. In the lower third of the linea alba (see Fig. 88) the conditions are different; here, the anterior half of the sheath of the rectus is far stronger than the posterior, being made up of the combined aponeuroses of the external oblique, the internal oblique, and the transversalis muscles. Hence, it is necessary to pull its anterior sheath well forward in suturing either by through-and-through sutures extending through all the coats of the abdominal wall or in a suture by layers. The posterior sheath is made up simply of the transversalis fascia, which is usually well approximated if the peritoneum has been brought into close apposition, being firmly attached to the latter.

For exploration of the gall-bladder region the incision is usually made through the right rectus, incising the aponeuroses of the abdominal muscles as they pass across the rectus to form its sheath.

For exploration of the right iliac, especially in appendicitis operations, the muscles are often divided in one direction,—that is, parallel to the fibers of the aponeurosis of the external oblique,—care being taken to avoid the deep epigastric artery, which lies between the transversalis fascia and peritoneum, its course being a line drawn from about the middle of Poupart's ligament to the umbilicus Figs. 75 and 79). This form of incision is made through all of the coats if it is not desirable to suture all of the abdominal wall at the time of examination; for example, in a case of suppuration, etc. On the other hand, if it is desired to suture the abdominal wound immediately and completely, the external oblique is divided by an incision carried obliquely downward and inward in the direction of its aponeurosis, the internal oblique is incised in the direction of its fibers upward and inward, and the transversalis in a transverse direction. Advantage is thus taken of the arrangement of the muscular fibers of these three large abdominal muscles, so that the best mechanical obstacle to a hernia is obtained, the direction of the incision in each interfering with the pressure from within, owing to the fact that one is placed almost at right angles to the other.

To operate upon the stomach, the incision is usually made along the left border of the rectus, close to the costal arch. To open the abdomen for the relief of intestinal obstruction, if it is desirable to establish an artificial anus, the incision is made in the left iliac region, in a similar manner to that made for appendicitis in the right iliac.

## Inguinal Region.

The **inguinal region and canal in the male** will be first described. The inguinal region of either side has as its boundaries Poupart's ligament, the median line, and a line drawn from the anterior superior spine of the ilium to the umbilicus (Figs. 75 and 76). The layers in this region are (1) skin and superficial fascia; (2) aponeurosis of the external oblique; (3) internal oblique and transversalis muscles, which are not attached to the inner half of Poupart's ligament; (4) transversalis fascia; (5) subserous connective tissue, in which the deep epigastric artery and vein lie; (6) parietal layer of peritoneum. The first four are traversed by the spermatic cord in an oblique direction, from without above, toward the median line below. The spermatic cord lies in the inguinal canal. There is no true canal under normal conditions; it is only open under pathologic conditions, when a viscus distends it. That is, it is a potential canal like the urethra, capable of being distended.

We may describe an external opening, or ring, an internal opening, or ring, and four walls. The external opening is formed by a split in the fibers of the external oblique aponeurosis, the **external abdominal ring,** the two boundaries of the ring being called the inner and outer pillars, of which the former is broader and thinner than the latter. The external ring is situated 2 to 3 cm. (1 inch) from the median line. Its size depends upon the intercolumnar fibers which bound the ring above. Normally, one can insert the tip of the index-finger into it in the adult, and the little finger in the child. It is largest when the thigh is everted. The **internal abdominal ring** lies nearly $\frac{5}{8}$ of an inch (15 mm.) above Poupart's ligament, midway between the symphysis pubis and anterior superior spine of the ilium (see Fig. 76).

The transversalis fascia is penetrated and sends a prolongation into the canal at the edges of the internal ring, known as the **infundibuliform fascia** (Fig. 77), which accompanies the cord and forms the **tunica vaginalis communis** (funiculi spermatici et testis). The inguinal canal is 4 to 5 cm. ($1\frac{1}{2}$ to 2 inches) long; it is traversed by the spermatic cord, which lies at first behind the transversalis muscle, then passes beneath the free edge of the transversalis and internal oblique, to the external ring (see Figs. 75 and 76). The anterior wall of the canal is formed

by the external oblique aponeurosis and by the fibers of the internal oblique (in its outer part); the posterior wall is formed by the conjoined tendon of the internal oblique and transversalis and the transversalis fascia. Its outer or lateral portion is strong, the inner or median weak, hence favoring the development of a hernia. The boundary between these two portions of the posterior wall is marked by the deep epigastric artery. The upper wall is formed by the arching fibers of the internal oblique and transversalis. The lower wall is formed by Poupart's ligament and at its inner part by Gimbernat's ligament. When the abdominal wall is examined from the inner side, a depression is seen opposite both the external and internal ring; through the former, the direct hernia makes its way; through the latter, the indirect (see Fig. 79). In addition to the above infundibuliform fascia, the spermatic cord receives as coverings the cremasteric fascia from the internal oblique, and intercolumnar or external spermatic fascia from the external oblique (see Fig. 77).

**Inguinal Hernia in the Male.**—A hernia which develops by passing through the internal abdominal ring, then traversing the entire inguinal canal and emerging at the external ring, is called an **indirect oblique inguinal hernia.** It lies, at first, external to the deep epigastric artery. The **direct inguinal hernia** is one which breaks through the posterior wall of the inguinal canal at the depression corresponding internally to the external ring, and pushes forward and appears at the external ring. Such a direct hernia always lies internal to the deep epigastric artery. A rarer form of hernia is the interstitial hernia, which develops in the inguinal canal or between the muscles of the same.
wall or between the muscles of the same.

**Indirect Hernia.**—Such a hernia enters with the spermatic cord at the internal ring, the cord lying to its inner side and behind. It traverses the inguinal canal and passes through the external ring into the scrotum. It may be congenital or acquired; the former, from the non-closure of the vaginal process of the peritoneum, which normally accompanies the spermatic cord and testis in its descent (see Fig. 78). Such congenital herniæ are most frequently developed after birth, when the tunica vaginalis testis is nearly formed, and are favored by the fact that in children the inguinal canal does not have an oblique direction, *but is almost straight through the abdominal wall.* A spontaneous cure may occur in such herniæ through the obliteration of the vaginal process. A hernia may develop in later life in the vaginal process of peritoneum, the latter remaining pervious for many years, until some sudden increase of intra-abdominal pressure forces the intestine into it. *In the acquired type there*

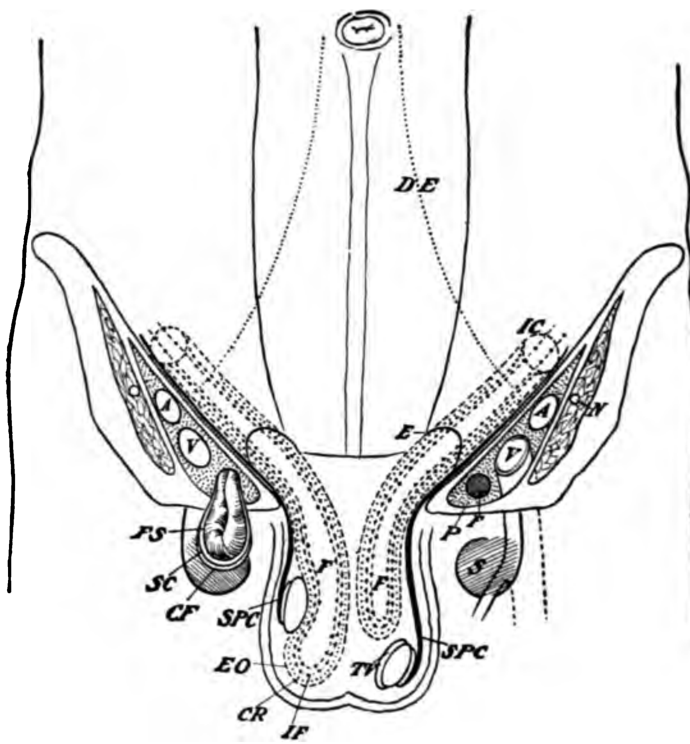


Fig. 77.—Coverings of inguinal (congenital and acquired) and of femoral herniæ. (Diagrammatic.) DE, Deep epigastric artery. IC, Internal abdominal ring. E, External abdominal ring. F, Interior of both inguinal hernial sacs. IF, Infundibuliform fascia. CR, Cremasteric fascia. EO, Intercolumnar fascia (external spermatic) from external oblique. SPC, Spermatic cord, lying on outer side of and behind sac. TV, Tunica vaginalis, not seen on opposite side because there is none in a congenital hernia, as shown on right side. A, Femoral artery. V, Femoral vein. F, Femoral ring, through which femoral hernia escapes. P, Gimbernat's ligament. N, Anterior crural nerve. S. Saphenous opening. FS, Peritoneal sac of femoral hernia. SC, Septum crurale. CF, Cribriform fascia.

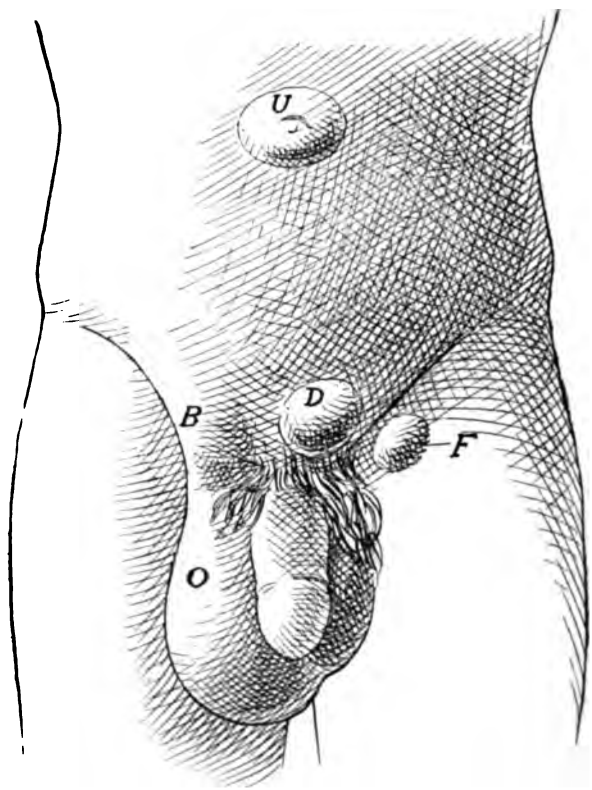


Fig. 78.—Location of various forms of abdominal herniæ (diagrammatic). *U*, Umbilical hernia. *D*, Direct inguinal hernia. *B*, Indirect incomplete inguinal hernia. *O*, Complete or scrotal inguinal hernia. *F*, Femoral hernia.


Fig. 79.—View of inner aspect of anterior wall of abdomen to show internal orifices of inguinal, femoral, and obturator herniæ. DA, Deep epigastric artery. E, Middle inguinal fossa, corresponding externally to external abdominal ring. A direct inguinal hernia passes directly outward through this depression without traversing the inguinal canal from I to E. This fossa is situated at the lower portion of Hesselbach's triangle. This triangle is formed by the deep epigastric artery on the outer side, Poupart's ligament below, and the remains of the hypogastric artery (H) and fold of peritoneum covering it on the inner side. Between H and U the internal inguinal fossa is to be seen. U, Remains of urachus, passing from anterior surface of bladder to umbilicus. I, Internal abdominal ring. Across its lower edge on either side is to be seen the spermatic artery and vein (S), and the vas deferens (D), passing into the inguinal canal, all lying extraperitoneally. V, External iliac artery and vein, as they pass under Poupart's ligament. F Femoral ring covered by septum crurale and peritoneum lying over it, through which a femoral hernia emerges from the abdomen. The internal abdominal ring is seen separated from the femoral ring by the deep epigastric artery. O, Obturator opening, through which an obturator hernia escapes from the abdomen. B, Superior surface of bladder. R, Rectum.

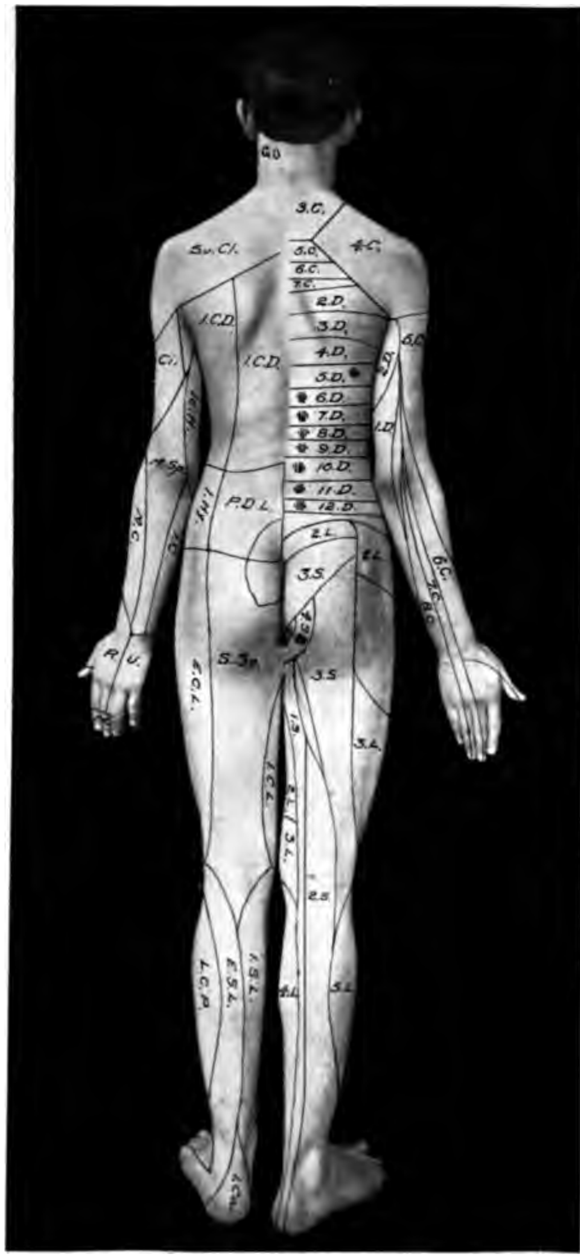


Fig. 80.—View of distribution of sensory nerves of the skin according to individual nerves (shown on the left side of the body), and of the same areas in relation to the segments of the cord (shown on the right side of the body). G.O., Area of occipital major. Su.Cl., Supraclavicular and acromial branches of the cervical plexus. I.C.D., Posterior branches of the intercostal nerves. P.D.L., Posterior branches of the lumbar nerves. I.Hy., Iliohypogastric area. C.I., Circumflex. Ic.H., Intercosto-humeral. M.Sp., Musculospiral. M.C., External cutaneous or musculocutaneous. I.C., Internal cutaneous. R., Radial. U., Ulnar. M., Median. On the right side of the posterior aspect of the body is seen the distribution according to segments of the cord, C standing for cervical, D for dorsal, L for lumbar, and S for sacral segments of the cord, respectively. (See section on Spine.) From the fifth to the twelfth dorsal segments on the right side, and in the fourth sacral segment of the same side, the maximum points, according to Head, for the abdominal viscera are shown. (See Abdomen.)

*is no preformed sac.* The peritoneum is simply pushed forward by the viscera or omentum. At first there may be only a bulging in the inguinal canal, or at the external ring, but sooner or later it escapes through the latter and passes along the spermatic cord into the scrotum (scrotal or complete hernia) (see Fig. 77). The shape of such a hernia is frequently that of a pear, and it may attain an enormous size. In cases in which the duration of the hernia has extended over a number of years, the canal itself may become obliterated, so that the external and internal abdominal rings are opposite each other. This variety is known as the straight hernia. The coverings of an indirect oblique inguinal hernia are skin, deep fascia of Cooper, intercolumnar fibers, cremaster muscle, infundibuliform fascia, and peritoneum (see Fig. 77). The contents may consist only of intestines (enterocele), or of omentum (epiplocele), or both. It may also contain any one of the more movable viscera; for example, the ovary or tube, the appendix, and occasionally the bladder. The deep epigastric artery always lies to the inner side of the neck of the sac, that is, the internal ring, the cord to the inside and behind. An indirect hernia lies along the outer edge of Hesselbach's triangle, which latter is formed by the outer border of rectus, inner third of Poupart's ligament, and deep epigastric artery (see Fig. 79).

A direct inguinal hernia pushes the posterior wall of the canal forward at its thinnest part (at floor of Hesselbach's triangle), where only the conjoined tendon of the internal oblique and transversalis muscles and transversalis fascia are present, at the depression which corresponds internally to the external ring (fovea externa) (see Fig. 79). It shows itself at the outer border of the rectus, internal to the deep epigastric artery, and presents externally at the external ring. The sac forms as the hernia develops. The hernial opening is usually quite large, admitting one to two fingers. The cord lies to its outer side. The form of the hernia is conical, generally the size of an egg. Its coverings are the skin, deep fascia, conjoined tendon, transversalis fascia, and peritoneum.

Strangulation of a hernia occurs when the contents are constricted so that the flow of blood in the vessels is obstructed. This rapidly causes intestinal paralysis, with resultant obstruction to the passage of the contents of the intestine. It is rare in the direct form of inguinal hernia, but frequent in the indirect, occurring usually at the neck of the sac, namely, at the internal ring. In incising such a constriction the relations of the deep epigastric artery must be borne in mind. It lies to the inner side (see Figs. 76 and 79).

An interstitial hernia is one in which the sac is developed in the inguinal canal, usually with ectopia testis. It may grow either between

the abdominal muscles, or through the external ring toward Poupart's ligament.

**Inguinal Canal in the Female.**—On account of the greater separation of the spines of the ilium, the canal is longer (5 to 6 cm.) than in the male. The rings are smaller, and the walls are closer together, only transmitting the round ligament. Hence, hernia is less frequent than in the male. The process of peritoneum (canal of Nuck) accompanying the round ligament lies to its inner side. In a hernia we may find, in addition to the contents in the male, not infrequently the adnexa. An inguinal hernia in the female may be either congenital or acquired; the latter is more frequent, as a result of the increased size of the round ligament during pregnancy, and its decrease after the same, leaving the canal larger. Such a hernia appears at the upper end of the labia majora.

The chief nerves which play a rôle in the anatomy of inguinal hernia are the last dorsal and two of the branches of the lumbar plexus, the iliohypogastric and the ilioinguinal nerves (Fig. 23). The latter two are the more important. The iliohypogastric lies between the transversalis and internal oblique above the crest of the ilium. About an inch in front of the anterior superior spine it pierces the internal oblique and continues its course in the groin beneath the aponeurosis of the external oblique. It becomes cutaneous by piercing the latter about an inch above the external abdominal ring. The ilioinguinal nerve accompanies the spermatic cord. It takes a course similar to that of the iliohypogastric, but at a lower level. It lies beneath the aponeurosis of the external oblique just above Poupart's ligament, accompanying the spermatic cord, and becomes superficial after passing through the external abdominal ring, and supplies the skin of the uppermost portion of the thigh and pubic region.

## Femoral Region.

Poupart's ligament, or the crural arch, is composed of an independent fibrous band which extends from the anterior superior spine of the ilium to the pubic spine, and amalgamates with the lower border of the external oblique aponeurosis. Its inner part forms Gimbernat's ligament. Beneath Poupart's ligament are two openings, one on the outer side for the iliopsoas muscle and anterior crural nerve, and one on the inner side for the femoral vessels. These openings are separated by the ilio-pectineal ligament (Fig. 101). The vessels are inclosed in a sheath formed by the extension of the iliac fascia (pectineal fascia) behind, and the transversalis fascia (fascia lata) in front (Fig. 75). An open space is

left to the inner side of the femoral vein, which is a fourth to half an inch long, begins at Gimbernat's ligament and extends to the saphenous opening, and is called the crural canal (Fig. 76). The upper end of this canal (crural ring) is covered by peritoneum and is filled by a plug of fat or a lymphatic gland, constituting the septum crurale. The deep epigastric artery separates (Fig. 79) the femoral ring fom the internal abdominal ring. Usually the canal only contains a small lymph-gland, and is, like the inguinal, a potential canal. It is funnel-shaped from the base downward to its apex, which lies just below Poupart's ligament under the saphenous opening on the inner side of Scarpa's triangle, so that a femoral hernia at first descends along the crural or femoral canal until it comes to the saphenous opening, and then passes upward toward the skin in the fold of the groin.

The femoral sheath is formed by the union of the fascia lata (pectineal fascia) and the continuation of the deep fascia (transversalis) of the abdominal wall into the fascia lata. Hence, a femoral hernia has lying behind it the pectineus muscle, being separated from it by the pectineal fascia (see Fig. 76). The anterior wall of the crural canal is thus formed by the superficial layer of the fascia lata, which, as stated above, is a continuation of the deep fascia of the abdomen, being attached to the outer portion of Poupart's ligament. Its posterior wall is formed by the deep or inner layer of the fascia lata or the pectineal fascia (continuation of the iliac fascia, as stated above). The femoral hernia pushes before it the peritoneum and septum crurale and descends along the femoral canal for a distance of one-fourth to one-half inch, until it comes to the saphenous opening. This saphenous opening is a gap in the fascia lata (iliac portion) which is not well defined on its inner side. It measures, vertically, one and a half to two inches, and is one inch external to the pubic spine. The outer edge of the opening is well marked and has a crescentic edge (falciform border) (Fig. 76). The internal saphenous vein crosses over its lower edge to empty into the femoral vein (Fig. 56). The remainder of the opening is filled in by some loose connective tissue and lymphatic glands. When a femoral hernia has come to the lower end of its canal, there is no other course left for it except to bend forward toward the skin, which it does by escaping through the saphenous opening, and thus receives a third covering, the cribriform fascia (Fig. 77), which is the name given to the above-mentioned loose connective tissue covering the saphenous opening. The septum crurale and cribriform fascia are often imperfectly formed, so that a femoral hernia may have as its covering only the peritoneum, subserous fat, and skin. The point of strangulation

of this variety of hernia is usually only at the saphenous opening, or at the femoral ring at the inner side of the femoral vein (Fig. 77).

An inguinal hernia lies above Poupart's ligament, a femoral hernia always below it (Fig. 77). The inguinal hernia emerges to the inner, the femoral to the outer side of the pubic spine. After emerging from the saphenous opening a femoral hernia may pass toward Poupart's ligament, so that it is impossible to distinguish it from an inguinal without considering the above points. The size of the femoral canal is greatest when the limb is flexed, adducted, and rotated inward, so that this is the most favorable position for the reduction of such a hernia. Femoral hernia is more frequent in females than in males, in a proportion of 4 to 1. It is favored by repeated pregnancies.

## Umbilical Hernia.

An umbilical hernia may be one of three varieties: (1) Congenital, due to non-closure of the opening in the fetus through which the umbilical cord with its vessels and remains of the omphalomesenteric duct have passed into the body; (2) the infantile variety, due to the incomplete closure of the umbilical ring; and (3) the adult type. Of these three varieties, the infantile type is by far the most frequent. The first variety is in reality a congenital defect, due to non-closure of the abdominal wall at the umbilicus. At a certain stage of the development of the embryo the anterior abdominal wall is open in the region of the umbilicus, and if this fails to close, the hernia is in reality an ectopia, analogous to a similar condition of the bladder, and may contain almost any one of the abdominal viscera. Such a hernia is covered by a thin layer of Wharton's jelly, and by a continuation of the parietal peritoneum in the form of a thin membrane. The congenital umbilical hernia may contain only a knuckle of intestine. It is not only of pathologic interest, but may become of great importance if the umbilical cord is tied too close to the body and a knuckle of intestine ligated with the stump.

The infantile type occurs especially in children who are subject to intestinal colic or constipation, or have phimosis, or may develop without any of these causes, in the following manner: Following the ligation of the umbilical cord after birth, the stump dries up and leaves a small granulating area which is rapidly covered with skin from the adjacent edges. Whenever there is increase of intra-abdominal pressure, the thin cicatrix which covers the umbilical ring (as the opening in the linea alba is called through which the cord passes) is stretched, and the peritoneum pushes the overlying, thin, umbilical and transversalis fascia and the skin before it. This is especially apt to occur near the upper margin of the

umbilical ring, where the umbilical vein enters and is loosely attached to the edges of the ring; so that an umbilical hernia, such as occurs in children, is in reality due to the stretching of scar tissue, and is the most favorable for non-operative treatment. Either pressure with a button or bringing the recti close together with adhesive plaster will cause the cicatricial tissue to re-form, and result in a healing of the hernia. Many of these heal spontaneously without any treatment, through new formation of cicatricial tissue over the ring.

The umbilical hernia of adults begins after the umbilical opening has been filled in by a firm scar tissue. It occurs especially in women after repeated pregnancies, and is due to stretching and relaxation of the abdominal walls. It may occur independently of disease in very stout individuals, owing to the stretching of the umbilical ring by the fat. They do not occur through the umbilical opening itself, but lateral to it; and have been called paraumbilical herniæ. The hernial ring in these cases is usually very firm. The coverings consist of the peritoneum, transversalis fascia, and skin. Most frequently its contents consist of omentum, which becomes firmly adherent to the interior of the hernial sac, as occasionally occurs in scrotal herniæ. The adherent omentum may divide the sac into a number of loculi or chambers.

This variety of umbilical hernia in adults is especially apt to become strangulated, owing to the firm fibrous character of the ring and the intimate relation of its contents to the sac. An anatomic point not to be forgotten in the treatment of all varieties of hernia which contain a large amount of omentum and intestine (this is especially true of umbilical hernia) is that in stout individuals with a short thorax the replacement of the contents of such a hernia into the abdominal cavity often causes serious interference with the action of the diaphragm, giving rise to fatal pulmonary conditions, the abdominal cavity not being able to accommodate itself rapidly to the largely increased contents.

## Lateral and Posterior Walls of the Abdomen.

The lateral and posterior walls of the abdomen include the region of the iliac fossæ and the lumbar region.

**Region of the Iliac Fossa.**—Both lateral and posterior regions of the abdomen are lined by one continuous fascia, which receives different names according to the region. Along the lateral and posterior walls of the abdomen the firm fascia which lies between the peritoneum and the muscles of the lateral abdominal wall (external oblique, internal oblique, and transversalis) is called the transversalis fascia. Above, the transversalis fascia is continuous with the firm fascia which lines the under surface

of the diaphragm. At the outer border of the quadratus lumborum muscle, the transversalis fascia is continued over the anterior surface of this muscle as a thin layer, forming the anterior layer of the lumbar fascia (see Figs. 83 and 84). At the crest of the ilium the transversalis covers the iliopsoas muscle, and is here called the iliac fascia. The iliac fascia really begins with the psoas muscle in the lumbar vertebræ, and covers the psoas until it joins with the iliacus, accompanying the iliopsoas muscle to the lesser trochanter (Figs. 81 and 100). It is attached to the inner border of the crest of the ilium, and internally to the brim of the true pelvis along the iliopectineal line. The portion covering the psoas is attached above to the ligamentum arcuatum internum and to the bodies of the lower dorsal and lumbar vertebræ.

Along the posterior wall of the abdomen a third fascia plays a rôle—the lumbar fascia (Fig. 83). This fascia divides into three layers—an anterior, a middle, and a posterior. It is attached internally to the spinous processes of the lumbar and sacral vertebræ. The posterior layer forms the aponeurosis of the latissimus dorsi. The anterior layer covers the anterior surface of the quadratus lumborum and is continued as the transversalis fascia. The middle layer, which covers the posterior surface of the quadratus lumborum, is continued into the transversalis muscle (Figs. 83 and 84). The upper portion of the most anterior of these layers constitutes the ligamentum arcuatum externum (Fig. 81).

A knowledge of the disposition of these fasciæ, and the fact that they are continuous with each other, are of considerable clinical importance for the following reasons:

First: An abscess or extravasation of blood between the transversalis fascia and the abdominal muscles is usually checked anteriorly and below at Poupart's ligament and the crest of the ilium, and behind at the anterior border of the quadratus lumborum. Owing to the fact, as stated above, that one of the ligaments of the diaphragm (ligamentum arcuatum externum) is formed by the lumbar fascia, an empyema may occasionally rupture, or work its way through the diaphragm or along this ligament, and appear between the last rib and the crest of the ilium as a fluctuating tumor whose posterior boundary is the anterior edge of the quadratus lumborum.

Second: In the same manner an appendiceal abscess may travel upward to the extraperitoneal tissue lying between the muscular structure of the diaphragm and the thick fascia separating it on its under surface from the peritoneum, giving rise to the extraperitoneal form of subphrenic abscesses. The lumbar fascia being continuous with the transversalis

fascia and transversalis muscle, pus from the sacro-iliac joint, from the bodies of the vertebræ, from the retroperitoneal lymph-glands, or from the kidney, may penetrate this fascia and travel to the surface between the iliac crest and last rib; or, through the communication of this fascia with that portion of the iliac fascia which covers the iliopsoas muscle, may open in addition above or below Poupart's ligament, or even work its way at the iliopectineal line beneath the pelvic fascia, around the pelvic viscera toward the outlet of the pelvis (see Fig. 103).

The iliac fascia is but loosely attached (see Figs. 83 and 84) to both the psoas and iliacus. A considerable amount of fluid may collect between these muscles and their fascia. A tubercular abscess due to disease of the last dorsal or upper lumbar vertebra along which the psoas is attached, gravitates downward to the iliac fossa, being limited at the brim of the pelvis and the crest of the ilium by the attachments of the fascia. It usually dissects under the fascia to the attachment of the muscle to the lesser trochanter (Fig. 138). Owing to the fact that the iliac fascia communicates at the brim of the pelvis with the pelvic fascia, abscesses beneath the latter, arising from the parametrium in the female, or from the prostate or rectum in the male, may dissect up the pelvic fascia until they arrive at the brim of the true pelvis, when they pass into the cellular tissue either between the iliac fascia and the iliopsoas muscle or between the fascia and the peritoneum, which is loosely connected with the fascia lining the iliac fossa, and appear above Poupart's ligament, where they can be opened.

Abscesses arising from the appendix may rupture into the extraperitoneal tissue of the iliac fossa, dissecting between it and the iliac fascia toward the kidney, or toward the lateral or anterior walls of the abdomen.

The remaining points of clinical interest in the iliac and lumbar regions are the following:

The iliac fossa contains the iliac artery and vein, the iliac glands, the spermatic vessels (see Figs. 88 and 101), and is crossed by the ureter. The peritoneum can be easily stripped from the iliac fascia here, so that the surgeon can work in this space with ease. The iliac glands receive lymph from the inguinal glands situated just above Poupart's ligament, so that a deep-seated suppuration may occur secondary to an infection of the inguinal glands in the iliac fossa (Fig. 59). These can be best drained by making an incision parallel to Poupart's ligament in the same manner as the method of ligation for the external iliac artery, through the abdominal muscles and pushing the peritoneum, which can be easily stripped from the iliac fasica, inward. In the interval between

the iliac fascia and the iliacus muscle, abscesses from disease of the vertebræ may lie, as stated above, passing along under Poupart's ligament to the lesser trochanter. In this layer also lie the anterior crural nerve and external cutaneous nerve (Fig. 101).

The genitocrural nerve lies on the psoas muscle on the outer sides of the common iliac vessels. Its genital branch enters the inguinal canal at the internal abdominal ring, supplying the skin of the scrotum. The crural branch continues with the psoas into the thigh, supplying the skin over Scarpa's triangle external to that supplied by the ilio-inguinal.

The obturator nerve lies in the iliac fossa for a short distance close to the pelvic brim near the inner border of the psoas, and then follows along the pelvic brim to the obturator foramen, through which it reaches the thigh, supplying the knee-joint and hip-joint (see Lower Extremity).

In the **lumbar region** the skin, like that of the iliac region, is thick and firm. The latissimus dorsi muscle lies quite superficially. At the crest of the ilium there is a small triangular space between it and the internal oblique, through which a hernia may arise; this is the triangle of Petit. The kidney rests upon the quadratus lumborum, separated only by a subserous fat layer and the very thin anterior layer of the lumbar fascia (the continuation of the transversalis fascia, see above), so that, in order to expose the kidney, the incision can be made either parallel with the outer border of the quadratus lumborum from the last rib to the crest of the ilium, or parallel to the last rib, dividing the posterior ends of the anterior abdominal muscles (internal oblique and transversalis) and incising the transversalis fascia (see Figs. 83 and 84).

The veins on the right side of the lumbar region lead into the vena azygos, on the left side into the vena hemiazygos. In case of obstruction of the iliac vein, aneurism, etc., they form anastomoses with the branches of the femoral vein on the outer side of the hip and lower portion of the abdomen and establish a collateral circulation. The lymphatics of the skin empty into the glands along Poupart's ligament.

The nerves supplying the muscles of the lateral and posterior abdominal wall are branches of the last five dorsal and first two lumbar nerves. They lie between the muscles, giving off three branches similar to the intercostal nerves, one posterior, one lateral, and one anterior, supplying the skin of the entire abdominal wall and pubic region, as well as the muscles themselves (Fig. 23). Hence, any irritation, whether a blow, or, in general, any form of sensory stimulation, whether heat, cold, tactile, etc., will cause a reflex contraction of the muscles of the abdominal wall; and, on account of the connection, as stated above, of these lower intercostal and lumbar nerves with the sympathetic ganglia supplying the

viscera, pain in the latter is referred to the corresponding point in the abdominal wall supplied by the same spinal segment.

This reflex contraction of the abdominal muscles and their mechanical arrangement at right angles to each other, serves as the best protection to the viscera from external violence, except such violence as may come so suddenly as to render a contraction impossible. If a blow is directed toward the skin of the abdomen, the reflex contraction of the muscles forms a fairly firm barrier against the force.

### The Abdominal Cavity in General.

This represents the largest serous cavity of the body. In males it has no communication with the external world; in females it has such communication through the Fallopian tubes and uterus. The entire cavity is lined by peritoneum (parietal), which at certain places (situated especially along the posterior wall) is reflected upon the viscera, forming one of their coats (visceral peritoneum). Other reflections serve as ligaments to suspend the organs, giving them a varying degree of range of motion.

The viscera which are partly covered by peritoneum, and thus become to some extent extraperitoneal, are the duodenum and pancreas, lower portion of rectum, bladder, and vagina. The kidneys, suprarenal capsules, ureters, and abdominal vessels all lie outside of the peritoneum, but inside of the abdominal cavity.

The liver, spleen, and female genitalia are rather firmly fixed by reduplications of the parietal peritoneum (ligaments) and have only a slight range of motion. The spleen is more mobile than the liver on account of the greater length and elasticity of its ligaments.

The reduplications or reflections of parietal peritoneum which suspend the hollow viscera, forming the alimentary canal, permit in general of a greater range of motion. This is especially true of the jejunum, ileum, transverse colon, and sigmoid flexure (iliac and pelvic colon). On the other hand, the duodenum, ascending and descending colon, and bladder are not completely covered by peritoneum, and are more fixed.

The stomach resembles the more solid viscera, like the spleen and liver, in having only a comparatively slight range of motion, depending to a great extent upon the dilatability of its walls, to accommodate the varying quantity of its contents.

The **peritoneum** has a very rich nerve and lymphatic supply. The nerves are derived chiefly from the lower dorsal and lumbar (spinal) and from the sympathetic nerves (Fig. 104). The surface dimension of the peritoneum is as great as that of the skin of the entire body. It follows, therefore, that a blow upon the abdomen may cause a temporary

paralysis of the vasoconstrictor nerves and permit nearly all of the blood of the body to collect in the vessels of the subserous layer of the peritoneum. The parietal peritoneum is far more sensitive to pain than the visceral, and, according to Lennander, but little pain is felt until the parietal peritoneum has been involved in an inflammatory process.

Many lymphatics lie in the subserous connective tissue, beneath the endothelial cells of which the peritoneum is composed. They are present in the form of interstitial lymph-spaces surrounding the cells, and pass directly over into the lymph-capillaries, being well marked in the central tendon of the diaphragm, where the greatest amount of absorption occurs. The stomata or openings between the cells, which communicate with the above-referred-to interstitial lymph-spaces, are largest there. Ten per cent. of a dog's weight can be absorbed by the peritoneum in thirty minutes.

The peritoneum, in addition to the power of absorption, has the equally important property of forming plastic, adhesive exudates which become rapidly organized, forming firm adhesions. These two faculties enable it to limit the spread of infection, by walling it off and by absorbing it.

Under normal conditions there is no peritoneal cavity, in the same manner as one cannot speak of a pleural cavity. There is usually only a capillary space left between the viscera, filled by a small amount of fluid which facilitates peristalsis. The parietal peritoneum is not firmly attached to the underlying fasciæ, except along the linea alba, and here especially around the umbilicus. Beneath it, in places, there are considerable masses of fat. The attachment is so loose that it enables the bladder, when full, to push the layer of peritoneum covering its fundus upward two inches, so that the anterior bladder wall can be opened (suprapubic cystotomy) without opening the general peritoneal cavity.

These divisions of the visceral peritoneum in the form of omenta, mesenteries, and ligaments, with the aid of the spinal column, divide the peritoneal cavity into a number of different spaces, which are of great interest from a clinical standpoint. First, the suspensory ligament of the liver and spinal column, down to the promontory of the sacrum, divide it into a right and a left half. It is also divided horizontally by the transverse colon with its mesocolon and omentum, especially when the latter is drawn up into an upper and a lower part. The upper part contains the stomach, liver, upper portion of the duodenum, pancreas, and spleen. The lower portion contains the small intestine from the duodeno-jejunal flexure to the ascending and descending colon, the rectum, and the pelvic viscera.


Fig. 81.—View of pelvic viscera (male) and retroperitoneal structures. PE, Reflection of peritoneum covering superior surface of bladder. R, Extraperitoneal space above pubes when bladder is full. U, Ureters. PC, Pelvic colon IC, Iliac colon, forming with PC what was formerly called the sigmoid flexure. DC, Descending colon. 1, Testis with epididymis, lying horizontally. Normally it lies vertically. 2, Spermatic cord. On the right side the spermatic vessels and vas deferens are seen free; on the left side they lie under the peritoneum at the brim of the pelvis. 3, Inferior vena cava. The right spermatic vein is seen arising upon its right side, near the kidney; left spermatic arises from the renal vein. 4, Aorta, at point where spermatic arteries are given off. 5, Aorta, just above celiac axis. 6, Is placed just above the superior mesenteric artery. 7, Inferior mesenteric artery. 8, External iliac artery and vein, as they pass beneath Poupart's ligament. The anastomosis can be seen between the deep circumflex iliac and lumbar veins. 9, Pouch between bladder and rectum. To the left of the figure 9 is the cavity of the pelvis. 10, Spermatic artery and vein. 11, Eleventh rib. 12, Twelfth rib.

The roof of the abdominal cavity is formed by the diaphragm. Beneath the diaphragm there is a right and a left subphrenic (Figs. 46 and 68) space formed by the suspensory or falciform ligament of the liver and by the spine. These right and left subphrenic spaces are again incompletely divided by the coronary ligaments into an anterior and a posterior compartment. In close relation with the left subphrenic space (see Fig. 68) is the left lobe of the liver, stomach, and pancreas; also the lesser peritoneal cavity, splenic flexure of colon, and spleen intraperitoneally, as well as the left suprarenal capsule and kidney extraperitoneally. Diseases of the stomach and pancreas may lead to abscess of the lesser peritoneal cavity, which communicates behind the hepato-duodenal ligament with the general peritoneal cavity through the foramen of Winslow. The right subphrenic space is in direct relation with the liver, and through a space lying behind the lower portion of the right lobe of the liver (retrohepatic space) in close relation with the upper portion of the duodenum and gall-bladder. The right subphrenic space is also in relation with the right iliac fossa along the outer side of the ascending colon (see Fig. 81).

This right subphrenic space can be best drained through an incision at the posterior portion of the right lumbar region.

In that portion of the abdominal cavity which lies below the transverse colon one can distinguish a central median portion containing part of the small intestines and the omentum, as well as the two lateral regions. The latter embrace, on each side, an iliac fossa and a lumbar region, with the portions of small intestine and colon corresponding to them, as well as the kidney of that side. The central portion is incompletely separated into a small right and a much larger left space, by the attachment of the mesentery (left side of second lumbar vertebra to right sacro-iliac joint). Both central and lateral portions, below the transverse colon, communicate with the pelvis.

In the male pelvis one can only speak of a single fossa, which is capable of containing coils of intestine and fluid (rectovesical) (Fig. 94); while in females there are two—the rectouterine, which is quite deep, and the rectovesical (Fig. 99).

In an upright position, or when the body of the person is bent forward, all parts of the peritoneal cavity can drain toward the pelvis except the lesser peritoneal cavity. When a person is lying down, pillows placed under the back facilitate drainage of fluid toward the pelvis. The tendency at the present time, in the drainage of intraperitoneal septic fluids which it is desired to have conveyed externally, is based upon the above anatomic fact; that is, setting the patient as nearly upright as possible. It has been proposed by some to elevate the pelvis and allow

the large lymphatics spoken of above, which lie in the diaphragm, to carry off the septic fluid. This has been abandoned to a great extent, on account of the great danger of intoxication.

The **most frequent points of origin of a peritonitis** are either the alimentary canal or the genital tract, especially of the female. Of all the organs of the abdomen, the appendix is most frequently the cause. In general, the causes in the alimentary canal are: (1) the perforation of an ulcer, due to some disease; (2) a phlegmon of the coats, with migration of bacteria through the walls; (3) ulcers situated above points of stenosis (decubitus); (4) traumatic perforation; (5) perforation of congenital diverticula (Meckel's); (6) strangulation due to any form of intestinal obstruction; (7) embolism, thrombosis, or injury of the mesenteric vessels (see below); (8) on the part of the liver, abscesses and suppurating echinococcus cysts; (9) all forms of pancreatitis; (10) cholecystitis and cholangitis; (11) puerperal and non-puerperal infections of the female genitals, the former being due to streptococci and the latter to gonococci; (12) embolic abscesses or suppurating echinococcus cysts of the spleen; (13) infection of the mesenteric lymphatics; (14) secondary to abscesses of the kidney; (15) abscesses of the prostate and periurethral abscesses; (16) transmission through the diaphragm from the pericardium and pleural cavities; (17) secondary to injuries and diseases of the abdominal wall; (18) secondary to infection of the umbilical cord in the new-born; (19) as a complication of pylephlebitis, which latter is secondary to an infection of the viscera.

The peritoneum can be described as consisting of two bags or sacs, a greater in front and a lesser behind, connected by an opening, the foramen of Winslow. The greater sac is made up of two layers, the parietal and the visceral.

The parietal lines the anterior, lateral, and posterior walls of the abdomen. Between it and the fasciæ lining these parts there is considerable areolar tissue in which the vessels, nerves, and lymphatics described above lie. In places this subserous tissue contains considerable fat (anterior wall). The peritoneum, through the aid of its subserous tissue, is loosely attached, except along the median line, so that it can be easily lifted up by collections of fluid (pus or blood). That pus can burrow beneath it in all directions is especially the case in the iliac fossæ and lumbar regions, where considerable amounts of fluid may accumulate beneath it.

When the parietal peritoneum reaches the inferior aspect of the diaphragm, it is reflected upon it, and from this point the visceral peritoneum can be followed (see Fig. 82).

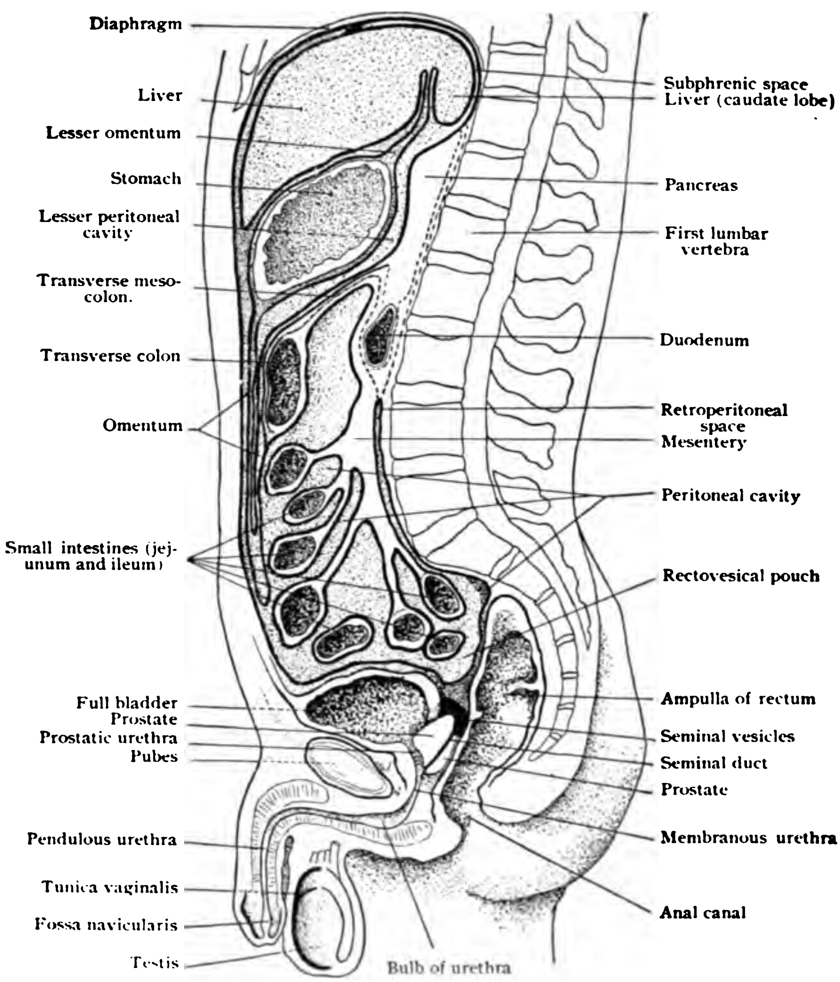


Fig. 82.—Sagittal section of abdomen in median line to show distribution of peritoneum (modified from Spalteholz).

The visceral peritoneum can be best understood by following it in a vertical section made in the median line of the body (see Fig. 82) and in number of horizontal sections of the abdomen made at different levels (Figs. 84, 86, and 88). A study of these sections will show the reflections of the visceral peritoneum to be in the form of mesenteries, omenta, and ligaments.

A **mesentery** means a double fold of peritoneum attaching a portion of intestine to the posterior abdominal wall.

An **omentum** is a fold connecting the stomach to the liver (gastrohepatic or lesser omentum), to the transverse colon (gastrocolic), and to the spleen (gastrosplenic). A **ligament** connects an organ with the abdominal parietes.

In a vertical section from above downward, the peritoneum forms the following reflections:

1. Coronary ligaments (reflection from diaphragm to liver), which are continued on each side as the lateral ligaments of the liver.

2. Covers liver (except at posterior surface for about two inches), and is reflected from inferior surface of liver to lesser curvature of stomach, forming—

3. Gastrohepatic or lesser omentum—now covers entire stomach, and then these two layers are reflected from the greater curvature to form—

4. Gastrocolic or greater omentum—in conjunction with two layers reflected from the spine covering the transverse colon (transverse mesocolon).

5. Behind the stomach, the four layers composing the greater omentum separate to form the lesser peritoneal cavity, which communicates with the greater cavity through the foramen of Winslow.

6. Below the attachment of the mesocolon the peritoneum is again reflected upon the small intestine (jejunum and ileum). The length of the mesentery is eight inches at its longest parts.

In addition to the above, there are a number of ligaments—phrenocolic, hepatoduodenal—which cannot be seen in a median section. In the vertical and horizontal sections (Figs. 82, 83, 84, and 86) the peritoneum can be seen to cover the anterior surface of the duodenum and pancreas, to be reflected (after lining the inside of the abdominal wall) upon the ascending, descending, iliac, and pelvic colon (sigmoid flexure), forming a mesocolon. Its pelvic portion forms a covering for the bladder and rectum in the male, and for the bladder, uterus, and rectum in the female. The peritoneum will be referred to again in connection with the individual viscera.

## The Liver.

The liver is divided into two lobes by a reflection of the parietal peritoneum lining the abdominal wall, called the falciform or suspensory ligament (see Figs. 67 and 83). If this ligament is cut, better access can be obtained for operations on the superior surface of either lobe. The liver is suspended from the diaphragm by a reflection of the peritoneum lining the under surface of that muscle called the coronary ligament. The **right lobe of the liver** occupies the right dome of the diaphragm, and the **left** occupies the center of the diaphragm, extending as far under the left dome as the mid-clavicular line (Fig. 46). As was stated above, there is direct communication between the subphrenic space, lying between the inferior surface of the diaphragm and the upper surface of the right lobe of the liver, and the general peritoneal cavity. This space is known as the right subphrenic space, and is not infrequently the seat of abscesses following appendicitis, liver abscesses, etc. The right lobe of the liver lies entirely behind the ribs, being in contact with the diaphragm, and separated from the thoracic cavity by this muscle. The relations of the pleura to the right lobe are of interest. The apex of the convexity of the right lobe extends as high as the fourth interspace (Fig. 68). From this point down, the greater portion of the entire convexity of the right lobe is in contact with the lower and middle lobes of the right lung and with the diaphragmatic pleura, so that abscesses either within the right lobe of the liver or between it and the diaphragm frequently cause an empyema through perforation into the pleural cavity, or they may give rise to an abscess of the lung through perforation into the usually adherent right lung (Figs. 67 and 68) On its anterior, posterior, and lateral surfaces the pleura extends down as far over the liver as the seventh rib in the mid-clavicular line, the lower border of the ninth costal cartilage in the axillary line, and the lower border of the eleventh rib (at about its middle) in the scapular line (Fig. 69). It thus becomes necessary at times, in order to explore or drain both the subphrenic space on the right side and the right lobe of the liver, to enter the pleural cavity (transpleural drainage). The left lobe is far more accessible through an abdominal incision than the right lobe. The right lobe is in close relation posteriorly with the right kidney, and the descending portion of the duodenum, as well as the hepatic flexure of the colon (see Figs. 69 and 83). The left lobe is in relation with the left kidney, and with the pancreas (see Figs. 69 and 84), and ascending portion of the duodenum. It also covers the greater portion of the stomach, being connected with it by the gastrohepatic or lesser omentum. Abscesses of the left lobe of the liver may rupture into the


**Fig.** 83.—Cross-section of abdomen at level of middle of kidneys and liver (first lumbar vertebra). S, Spleen. LK, Left kidney. RK, Right kidney. QL, Quadratus lumborum muscle. CE, Nerves of cauda equina projecting from spinal canal. P, Pancreas. V, Stomach, close to cardiac orifice. D, Thoracic duct. T, Ligamentum teres or suspensory ligament of liver. LL, Left lobe of liver. LF, Longitudinal fissure of liver. RL, Right lobe of liver. 1, Aorta. 2, Vena cava inferior. 3, Gastrohepatic or lesser omentum. 4, Gastrosplenic omentum.

left subphrenic space, or, through adhesions with the diaphragm, into the left pleural cavity. In children the liver is relatively larger than in adults and occupies a large part of the upper half of the abdomen.

On the inferior surface of the right lobe is the **gall-bladder,** which is usually quite firmly adherent to it. Its position may change with the size of the liver, but, in general, it may be said to be opposite the ninth right costal cartilage, at its junction with the right rectus muscle (Fig. 73). The gall-bladder is supplied by a branch of the hepatic artery, called the cystic artery (Figs. 73 and 90). This enters the gall-bladder close to its neck, and may give rise to a severe hemorrhage, if severed. The position of the gall-bladder with relation to the abdominal wall can be best understood from figures 68, 73, and 84. It will be seen that the fundus is at a lower level than the neck. The *cystic duct* has a rather tortuous course, and in its interior it has a number of valve-like folds of mucous membrane, known as Heister's valves, which prevent an exploration of the cystic duct from the fundus with the sound. At the inferior surface of the liver (transverse fissure) the cystic and hepatic ducts join at an acute angle to form the *common duct.* They lie in the hepatoduodenal ligament, on the upper side of the foramen of Winslow. The common duct is described below in connection with the duodenum. The *hepatic duct* is in close proximity to the hepatic artery, which enters the liver close to the point of emergence of the hepatic ducts for the right and left lobes. At this point one also finds the portal vein lying obliquely from right to left (Fig. 90). All of these structures lie behind and above the pylorus.

**Gall-stones** may occur in the hepatic ducts, either within or external to the liver, in the gall-bladder proper, or in the cystic or common ducts. They may lie dormant in the gall-bladder throughout life, without giving rise to any symptoms, but, as Riedel has pointed out, any infection of a gall-bladder containing gall-stones gives rise to the collection of a large amount of serum within the organ, and causes an attack of cholecystitis (gall-stone colic), with expulsive efforts on the part of the musculature of the gall-bladder—which, in the majority of cases, are unsuccessful—to expel the stone through the cystic duct into the common duct. The gall-bladder narrows toward the cystic duct, and there are often diverticula here in which stones are lodged. The cystic duct will seldom permit a stone of larger caliber than a small pea to pass through it. The stones in the common duct, through obstruction to the flow of bile, cause either intermittent attacks of jaundice through a ball-valve action, as pointed out by Fenger, or a more or less severe and permanent jaundice through chronic obstruction to the flow of bile. Gall-stones in the gall-bladder seldom give rise to jaundice, and, if so, only

slight (inflammatory). As stated below, a gall-stone lodged near the common opening of the pancreatic duct and common bile-duct may give rise to an inflammation of the pancreas (Fig. 91). The constant presence of the stones as irritants is not infrequently the starting-point of a carcinoma of the gall-bladder or of the bile-ducts.

A catarrhal inflammation of the duodenum may occlude the orifice of the common bile-duct at the ampulla of Vater and also give rise to retention jaundice (catarrhal icterus). Micro-organisms are less abundant in the duodenum than in any other portion of the intestinal tract, increasing in number from this point downward. Nevertheless, under certain conditions colon or typhoid bacilli may wander upward along the bile-passages, and give rise to an inflammation of the gall-bladder or inflammations of the intrahepatic bile-passages (angiocholitis). These inflammations may be either catarrhal or suppurative; if the latter, they give rise to multiple abscesses within the liver. The liver receives blood from the stomach, spleen, small and large intestines through the portal vein, so that any suppurative condition in these viscera (appendicitis, dysenteric colitis, etc.) may, through an intervening inflammation and thrombosis of the corresponding branch of the portal vein (pylephlebitis), give rise to metastatic abscesses in the liver.

## The Stomach.

The stomach lies in the left hypochondriac and epigastric regions. It is fixed to the diaphragm through the medium of the esophagus, and to the liver through the medium of the lesser omentum and hepatoduodenal ligament, which is the continuation of the gastrohepatic or lesser omentum; lastly, through the medium of the duodenum, it is anchored to the spinal column.

The stomach is divided, for convenience, into the cardia, or cardiac end, which lies close to the opening of the esophagus; into the fundus, which extends about an inch above the cardiac end and partly fills the left dome of the diaphragm (Figs. 68 and 69); into the body of the stomach proper, which includes the greater portion of the anterior and posterior walls with the greater and lesser curvatures; and, lastly, into the pyloric portion, the latter being situated in the neighborhood of the sphincter muscle, which marks the passage of the stomach into the duodenum.

Only the pylorus and half of the greater curvature lie free and uncovered in apposition with the anterior abdominal wall. The remainder is covered by the left lobe of the liver (see Figs. 68 and 83) and by the ribs, being separated from the chest wall by the diaphragm, left lung, and


Fig. 84.—Cross-section of abdomen at level of second lumbar vertebra. G. Fundus of gall-bladder. L, Right lobe of liver. D, Vertical portion of duodenum (second portion). DJ, Jejunum close to duodenojejunal flexure. SC, Splenic flexure of colon, seen twice, because the two limbs ran parallel. RK, Right kidney. LK, Left kidney. O, Omentum. P, Psoas muscle. QL, Quadratus lumborum. CE, Nerves of cauda equina, hanging out of spinal canal. 1, Abdominal aorta. 2, Inferior vena cava. 3, Coils of small intestine cut transversely. Their relation to the omentum is to be noted. These coils are probably portions of the jejunum. 4 and 5, Renal vessels. 6, Peritoneal cavity. During life such a space does not exist, the omentum and the liver being in direct contact with the parietal peritoneum. The peritoneum (white line) should be followed to the right and left from this point. 7, Left rectus muscle. In this portion of the abdomen note the formation of the anterior and posterior halves of its sheath (see text) by the external oblique (10), internal oblique (9), and transversalis muscles (8). On the left side the abdominal muscles of the anterior abdominal wall should be followed backward, where their relation to the lumbar fascia can be studied.

pleura as far downward as the seventh rib in the mid-clavicular line. The fundus is in close relation under the left dome of the diaphragm with the pericardium (see Figs. 46 and 68), so that when distended it pushes the left half of the diaphragm upward, and can readily interfere with the perfect action of the heart, and thus a flatulent dyspepsia may cause the patient to believe that he has heart disease. Behind the stomach, at the lower portion of its posterior wall, the pancreas lies, along the upper border of which runs the large splenic artery from right to left (see Figs. 74, 83, and 90). This relation explains the possibility of an erosion of this artery through an ulcer on the posterior wall of the stomach.

On account of the relation of the posterior wall of the stomach to the lesser peritoneal sac (forming its anterior wall), the contents of the stomach may escape after perforation of the posterior wall into this sac (Fig. 82), and either become encapsulated here, or take one of two courses: through the foramen of Winslow, which lies close to the pylorus, into the general peritoneal cavity, or toward the left subphrenic space, abscesses arising from the stomach being one of the most frequent causes of left-sided subphrenic abscess.

The anterior wall, as stated above, is covered to a considerable extent by the left lobe of the liver. The cardiac portion is quite deeply situated, and not readily accessible. The pyloric portion lies in the epigastric region about one inch to the right of the median line, at a point about midway between the ensiform process and the umbilicus. When empty, the stomach has a far more vertical position than was formerly thought. The lesser curvature of the empty stomach runs obliquely downward from left to right. The greater curvature has a similar course. As the stomach fills, both of these become more horizontal, so that when the stomach is full the greater curvature lies horizontally at a point about two inches above the umbilicus.

The stomach even under normal conditions may extend as far as the umbilicus, but if it extends below it, one of two conditions is present: either the stomach has fallen in its entirety, both lesser and greater curvatures being at a lower level than normal—a condition called gastroptosis, or falling of the stomach, due to relaxation of the ligaments holding it in place; or, secondly, a condition known as dilatation of the stomach exists, in which the lesser curvature remains at approximately its normal level, whereas the greater curvature is at a much lower one, even extending at times to the symphysis pubis in extreme conditions. Such dilatation is usually due to an obstruction at the pylorus.

The average capacity of the stomach is 1500 cubic centimeters, but it may vary considerably within normal limits. The mucous membrane

is much longer than the other coats, causing it to be folded or corrugated.

The greater curvature is connected with the transverse colon through the medium of the gastrocolic omentum. The pylorus has a distinct thickening of muscle, being here about 3 to 4 mm. in thickness. Under normal conditions the pylorus admits the index-finger when the walls of the stomach are invaginated into it. This is a valuable test to determine whether there is any obstruction at the pylorus. Such an obstruction may be due to a benign or malignant growth, or is not infrequently due to simple muscular hypertrophy, or, as may occasionally be the case at the esophageal end, due to a spasm of the muscles. Another cause of obstruction of the pylorus is the cicatrix due to the healing of a round ulcer. To relieve such an obstruction at the pylorus, an operation known as gastro-enterostomy is frequently performed, consisting in bringing the jejunum into the anterior or posterior walls of the stomach, which establishes a shorter route for the contents of the stomach, instead of passing through the pylorus into the duodenum. Under these conditions, if the pylorus is still patent, there may be regurgitation of the bile and pancreatic fluid into the stomach, causing obstinate vomiting, and even resulting fatally (vicious circle).

The stomach is connected with the spleen by a prolongation of the greater omentum (see Fig. 83), the gastrosplenic omentum, which assists in anchoring the stomach laterally to a slight extent.

The stomach receives a rich **blood-supply** through the medium of the vessels which run along its lesser and greater curvatures. The left and right coronaries run along the lesser curvature; the right and left gastro-epiploic arteries run along the greater curvature. The vessels for the greater curvature are derived from the hepatic artery (right gastro-epiploic, a branch of the gastroduodenal) and from the splenic (left gastro-epiploic). The hepatic artery gives off the pyloric artery (arteria gastrica dextra) which joins with the left coronary or gastric artery (arteria gastrica sinistra), a branch of the celiac axis, to supply the lesser curvature. These vessels send off branches which run almost vertically on the anterior and posterior wall and anastomose freely with each other, so that the blood-supply of the stomach does not come from one mesentery, but from two; that is, above and below (Fig. 90). Hence there is less danger of gangrene than is the case with the small intestine and colon, where the sole source of blood-supply is along one mesentery, the single mesentery which sustains them.

The veins empty chiefly into the portal vein. The right gastro-epiploic joins the superior mesenteric (see Fig. 90), the left gastro-epiploic

joins the splenic, and the coronary or gastric vein and pyloric vein (corresponding to the same named arteries) also join the portal (Fig. 90). The coronary or gastric vein receives an esophageal branch, so that in this manner there is communication at the cardiac end of the esophagus between the two venous systems.

In cases of cirrhosis of the liver, when there is obstruction of the portal circulation, a large quantity of the blood, instead of returning to the liver through the portal vein, utilizes this channel between the two systems and returns to the vena cava through the medium of the esophageal veins, which become enormously increased in size and varicosed, and may occasionally, as do varicose veins elsewhere, rupture and give rise to the severe gastric hemorrhages occurring in cirrhosis of the liver.

The walls of the stomach are richly supplied with lymphatics, which pass to four sets of glands: (1) those in the greater omentum along the greater curvature; (2) those in the lesser omentum in the lesser curvature; (3) those around the cardiac end of the stomach situated on its wall; and (4) those along the upper border of the pancreas, to which the glands along the left half of the greater curvature lead.

The lymphatics end sharply at the pylorus, so that the transmission of a carcinoma from the pylorus to the duodenum seldom occurs. The demarcation at the cardiac end is not so sharp, hence the supraclavicular glands may be enlarged in carcinoma near this end.

## The Small Intestine.

The small intestine is the portion of the alimentary canal which is placed between the stomach and the beginning of the large intestine. It commences at the pylorus and ends at the ileocecal valve, and is divided into three portions—the duodenum, jejunum, and ileum. Its entire length is eight yards; that is, twenty-four feet, according to Sappey. The duodenum, or first portion, corresponds to a portion of a spiral; that is, it is ring-like.

The **entire duodenum** is 12 inches (30 cm.) long, and is wider than the remainder of the small intestine (1½ to 2½ inches—4 to 6 cm.). It has a shape like the letter C, embracing the head of the pancreas. The first or horizontal portion begins at the pylorus, opposite the first lumbar vertebra (Figs. 73, 74, and 83). It is entirely covered by peritoneum, and is held in place by a continuation of the lesser omentum, the hepato-duodenal ligament. It bends in front of the kidney and ends at the neck of the gall-bladder, at which point the second or vertical portion begins, at the side of the first lumbar vertebra. This portion is in direct contact with the transverse colon and lies behind it, and ends at the right side of

the third or fourth lumbar vertebra (Fig. 69). On its outer or right side it is in relation to the liver; on its inner, to the inferior vena cava and head of the pancreas, the latter overlapping it somewhat in front (Fig. 74). The relations of this second or vertical portion of the duodenum to the bile and pancreatic ducts are of great practical value. The **common bile-duct** runs behind the first portion of the duodenum, and then descends between the head of the pancreas and the second portion, nearly as far as the middle of the latter (Fig. 73). The duct is accompanied by the portal vein (lying to its left), and the hepatic artery (lying to its right) (Fig. 90). All of these structures lie in the hepatoduodenal ligament, which may be made more prominent by passing the finger behind the ligament, the latter forming the anterior wall of the foramen of Winslow. The common bile-duct continues behind the vertical portion of the duodenum (see Fig. 73) and joins with the pancreatic, opening into the duodenum obliquely after running nearly an inch (2 cm.) through its wall. There are, therefore, three portions of the common bile-duct: The portion above the horizontal part of the duodenum is called the supraduodenal portion; the portion behind the vertical or second portion of the duodenum, the retroduodenal; and the portion which passes through the head of the pancreas to join the pancreatic duct, the intrapancreatic portion. The common orifice by which the pancreatic duct and the common bile-duct open into the duodenum is called the ampulla of Vater. It lies about $3\frac{1}{2}$ to 4 inches below the pylorus. Not infrequently an accessory duct of the pancreas opens into the duodenum a little above the ampulla of Vater (about $\frac{3}{4}$ of an inch). **The relations of the head of the pancreas** to these ducts and to this second or descending portion of the duodenum are of the greatest practical value (Fig. 73). As was stated above, gall-stones occur not only in the gall-bladder and intrahepatic ducts, but also in the common duct. When they are present in the common duct, they are most accessible to operative removal in the supraduodenal portion. When they lie at the junction of the common bile-duct and pancreatic duct, they not only obstruct the flow of bile, but also the flow of pancreatic fluid, as Opie has recently pointed out. Such a stone, lodged near the ampulla of Vater, will permit organisms to enter the pancreatic duct, causing an acute inflammation of the latter (acute hemorrhagic pancreatitis), or may give rise to a cyst of the pancreas (see Pancreas). In a similar manner, a stone lying in the common duct will allow organisms to enter through the ampulla and cause the inflammation of the bile vessels referred to above (angiocholitis). The persistence of the accessory pancreatic duct may also be of assistance in explaining the origin, at times, of inflammation of

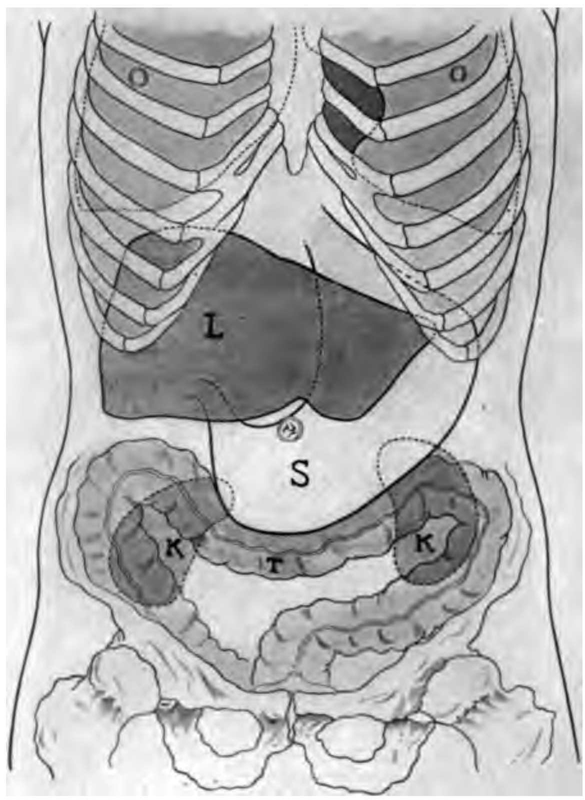


Fig. 85.—Front view of a case of general enteroptosis (R. C. Coffey). L, Liver outline on surface, showing marked descent. S, Stomach. Note the fact that the lesser curvature lies at the level of the umbilicus and the greater curvature midway between the umbilicus and symphysis. K.K, Right and left kidneys, showing marked downward displacement. T, Transverse colon, also markedly prolapsed.


Fig. 86.—Cross-section of abdomen at level of third lumbar vertebra. L, Lumbar vertebra. The nerves of the cauda equina are seen projecting from the spinal canal. P, Psoas muscle. QL, Quadratus lumborum. ES, Erector spinæ, or sacrospinalis. IL, Iliacus muscle, lying on inner side of ilium, which has been cut through on the right side. A, Ascending colon. D, Descending colon. Note the fact that the posterior surfaces of A and D are not covered by peritoneum. O, Omentum. T, Transverse colon, just before passing into splenic flexure, seen in cross-section. The letter T in the center of the picture is placed upon the outer surface of the transverse colon. H, Hepatic flexure of colon, upon which rested that portion of the liver and gall-bladder seen in figure 84. 1, Vena cava inferior. 2, Aorta. 3, Ureters. 4, Spermatic artery of right side. 5, Anterior layer of lumbar fascia. 6, Middle layer of lumbar fascia. The outer layer of lumbar fascia is represented by the white line covering LD, the latissimus dorsi, and ES, erector spinæ. Note the relations of the abdominal muscles of the anterior wall to the lumbar fascia; also in the upper portion of the picture the formation of the sheaths of the recti. (Compare this picture with Figs. 67, 83, 84, 88, and 89, in order to understand the change in relations at different levels of abdomen.)


Fig. 87.—Front view of case of carcinoma of the head of the pancreas. The area of liver dullness is outlined in black. *R*, Right lobe of liver. *L*, Left lobe of liver. The notch between the two lobes could be distinctly palpated to the left of the median line at the level of the umbilicus. *G*, Enormously distended gall-bladder easily palpable through the abdominal wall. Enormous size of the liver was due to passive hyperemia and to secondary deposits in the liver parenchyma. The yellowish color of the skin was due to pressure on the common duct.

the pancreas. Carcinoma of the head of the pancreas through involvement of the common bile-duct will cause jaundice and obstruction of the flow of pancreatic fluid, as well as ascites through pressure upon the portal vein lying immediately to the left of it (Fig. 90). The relation of both the horizontal and descending portions of the duodenum to the upper and lower poles of the right kidney renders it possible (see Fig. 83) for abscesses of this kidney to empty into the duodenum.

The third or ascending portion of the duodenum crosses the spinal column at the level of the third lumbar vertebra, reaching the left side of the spine opposite the first or second lumbar vertebra, where it ends in the jejunum (Fig. 69). It is crossed here by the superior mesenteric vessels and the portal vein. The duodenojejunal flexure lies at the level of the first lumbar vertebra. It has a direction from behind forward (see Fig. 69). Only the anterior aspects of both the second and third portions of the duodenum are covered by peritoneum. The posterior wall is firmly adherent, through loose areolar tissue, to the kidney, abdominal aorta, vena cava inferior, lumbar portion of the diaphragm, and spinal column (Fig. 83). These relations cause the greater portion of the duodenum to be firmly fixed to the posterior abdominal wall, and permit of only slight movement, so that if a rupture of this portion of the intestine occurs, it is always at the junction of the fixed and movable portions—the duodenojejunal flexure.

The remainder of the small intestine is wider above—25 to 35 mm. (1 to 1½ inches)—than below,—20 to 25 mm. (¾ to 1 inch). The coils of the jejunum occupy in general the upper and left portion, and the ileum, the lower and right portions of the area in which the small intestines lie. In general, the **jejunum and ileum** are separated from the abdominal wall by the omentum (Fig. 86), and when this is retracted, they are in direct contact with the parietal peritoneum. They lie chiefly in the umbilical and hypogastric regions, but overlap the colon (ascending and descending) in the lumbar and iliac regions of each side. They lie, as it were, in a frame formed by the ascending, transverse, and descending colon. Their mesentery varies in length, being longest about 20 to 25 cm. (8 to 10 inches) above the cecum, and again becoming shorter 15 cm. (6 inches) above the ileocecal valve, so that the middle and a little below the middle portion of the jejunum and ileum have the most mobility, and hence are frequently found in inguinal and femoral herniæ. Where the duodenum passes into the jejunum, there is a blind pouch or sac—the fossa duodeno-jejunalis. In rare cases it may contain a coil of small intestine, giving rise to a retroperitoneal hernia. The mesentery which suspends the jejunum and ileum has its line of attachment from the left side of the

first lumbar vertebra in an oblique direction downward and to the right, as far as the front of the right sacro-iliac joint. To find the jejunum, the omentum and transverse colon should be lifted up, the small intestines pushed to the right, when it can be found immediately below the pancreas. The arterial supply of the jejunum and ileum is derived from the superior mesenteric (Fig. 90). In atheromatous conditions this artery occasionally becomes the seat of an embolus, or is occluded by a thrombus, resulting in severe symptoms resembling those of intestinal obstruction, bloody stools, vomiting, severe pain in the abdomen, etc. The veins empty into the superior mesenteric vein, a branch of the portal (Fig. 90). A thrombosis of these veins causes gangrene of the loop of bowel which they supply, and a septic phlebitis may extend upward to the liver, and cause an abscess. The lymphatics lie in the submucous and muscular coats, as in the stomach, and empty into the mesenteric glands, about two hundred in number, which empty into the thoracic duct. These glands become enlarged quite early in all infectious processes of the intestine (typhoid, dysentery, appendicitis), and in tuberculosis may become so large as to resemble tumors. After attacks of appendicitis they are apt to become greatly enlarged in that portion of the mesentery and mesocolon close to the cecum.

## The Large Intestine.

The large intestine is about nine feet in length; it begins at the cecum, which lies close behind the anterior abdominal wall in the right iliac region (Figs. 68 and 88). From the lower back portion of the cecum is the most frequent point of origin of the **appendix**; since the position of the cecum varies to some extent, so does that of the appendix. The most typical position is for it to hang downward over the pelvic brim (Fig. 68), although it may point toward the kidney, liver, bladder, or even lie extraperitoneally behind the cecum. The average length of the appendix is 5 to 8 cm. This is also subject to variation. The appendix gradually becomes obliterated toward old age. The appendix is suspended by a prolongation of the mesocolon known as the mesenteriolum, in which are several arteries and veins, as well as lymphatics. The cecum and appendix lie upon the peritoneum of the right iliac fossa (see Fig. 88), in close relation to the iliac vessels at the pelvic brim. The appendix being entirely covered by peritoneum, an inflammation with perforation of its coats will cause the contents to be extravasated directly into the general peritoneal cavity, unless the process is walled off through adhesions of the omentum, adjacent small intestines, colon, and parietal peritoneum.

In figure 92 are shown the places in the abdomen in which abscesses


Fig. 88.—Cross-section of pelvis at level of sacro-iliac joints. S, Sacrum. I, Ilium. SC, Iliac colon (sigmoid flexure). C, Cecum, and beginning of ascending colon. 1, Placed to inner side of each sacro-iliac joint. 2, Ureters. 3, Mesosigmoid, showing great length of latter. 4, Pelvic colon not cut, seen from above. 5, Omentum. 6, External iliac artery. 7, External iliac vein. 8, Iliopsoas muscle. The white dot above it is the anterior crural nerve. 9, 10, and 11, Gluteal muscles.


Fig. 89.—Cross-section of female pelvis at level of lower portion of coccyx. C, Coccyx. G, Gluteal muscles. B, Obturator internus. I, Ischium and descending ramus of pubes. F, Head and neck of femur. P, Pectineus muscle. R, Rectum, seen in cross-section. One of Houston's valves is seen on the right edge. V, Vagina, the light spot at the anterior margin represents the external orifice. U, Cross-section of urethra. 1, External iliac vein lying upon the pectineus muscle. 2, External iliac artery. 3, Anterior crural nerve. 4, Parietal layer of pelvic fascia. 5, Inferior vesical artery. 6, 7, 8, and 9 Muscles on anterior aspect of thigh (iliopsoas, pectineus, and sartorius).

most frequently occur, either directly or indirectly, as the result of appendicitis. The most frequent point is in the immediate neighborhood of the ileocecal region, about 50 per cent.; the next most frequent point is behind the cecum; then the abscesses occurring around the pelvic organs, especially between the rectum and vagina, where they can be drained through an incision in the lateral wall of the rectum. The proximity of the appendix to the Fallopian tube renders the transmission of infection from one to the other easy. The relation of such intraperitoneal abscesses to the adjacent hollow viscera will explain the frequency with which they perforate into the small and large intestines, bladder, and rectum. The abscesses not infrequently become extraperitoneal through adhesions to the abdominal parietes, burrowing down even under the pelvic fascia, so as to simulate ischiorectal abscesses. The posterior portion of the **cecum** is generally not covered by peritoneum. At times the cecum may have such a long mesentery, however, that it enters a hernial sac, giving rise to the form known as cecal hernia. Beneath the cecum there is a blind pocket or pouch of peritoneum known as the fossa subcæcalis, which may also be the seat of a hernia. The **ascending colon** ascends between the iliacus and psoas, close to the posterior wall of the abdomen, until it reaches the lower surface of the liver, where it turns into the transverse colon (hepatic flexure) (Fig. 50). It lies along the outer edge of the quadratus, and comes in close contact with the right kidney (Figs. 69 and 86). Only its external and anterior surfaces are free and covered by peritoneum (see Fig. 86). Its internal and posterior surfaces are closely adherent to the underlying structures. The **transverse colon** passes toward the anterior wall of the abdomen again, across the upper border of the umbilical region, passing again toward the posterior wall of the abdomen, where it reaches the lower end of the spleen (Figs. 50, 69, and 86). It is suspended from the stomach by the transverse mesocolon, and hanging down from its lower edge is the great omentum. The lengths of the transverse colon and of its mesentery vary greatly, so that the loop may extend into the pelvis. At the splenic flexure the colon is fixed to the spleen by a continuation of the greater omentum—the phrenocolic ligament. At the splenic flexure the turn of the colon is so abrupt that the two portions may lie parallel to each other (Fig. 86). The **descending colon** lies also close to the posterior abdominal wall, coming in close contact with the left kidney, the spleen, and the pancreas (see Figs. 80, 86, and 88) until it passes over, at about the crest of the ilium, into the iliac colon or sigmoid flexure. The descending colon, like the ascending, is covered by peritoneum only on its external and anterior aspects (see Figs.

86 and 88) and has a very short mesentery, being adherent along its posterior aspect to the kidney and retroperitoneal connective tissue. Abscesses arising from the posterior wall of the ascending or descending colon penetrate into the extraperitoneal tissue. The **iliac** and **pelvic colons** (sigmoid flexure in older terminology) extend from the left upper crest of the ilium to the middle of the sacrum, the pelvic beginning at the brim of the pelvis. It has a very long mesentery (Fig. 88), and is most frequently used to form an artificial anus in the left iliac region. On account of its long mesentery, it readily becomes twisted, giving rise to volvulus, a form of intestinal obstruction.

The **rectum** begins about the middle of the sacrum, and will be described with the pelvis.

At the junction of the ileum and cecum there are two folds of mucous membrane (ileocecal valve) which prevent regurgitation from the cecum to the ileum. The stomach contents remain acid in the lower portion of the duodenum, where they are mixed with bile and pancreatic fluid. This decreases the acid reaction, but the latter remains until the contents reach the colon. At the ileocecal valve the intestinal contents are thick, acid in reaction, light yellow to green in color. The majority of the absorption takes place from the ileum and colon. The function of the colon is chiefly to absorb the water; that is, to inspissate the refuse bowel contents. The contents of the stomach require three to six hours to travel from the stomach to the ileocecal valve, and from this point to the rectum about twelve hours. From the duodenum downward the number of micro-organisms in the alimentary canal increases, becoming greatest in the large intestine, where putrefaction begins. The amount of indican in the urine is an index of the amount of putrefaction in the colon. In addition to the water-absorption properties of the colon, the rectum and a portion of the pelvic colon have the power of absorbing peptones, sugars, and emulsified fats. This fact is utilized in rectal feeding, it being possible for the system to be nourished for a number of days or weeks through the capacity of this portion of the bowel to absorb nutriment. In thin persons the ascending and descending colon may be felt deeply situated in the abdominal cavity as firm cords, at times resembling tumors. The ascending, transverse, and a portion of the descending colon are nourished by the colic branches of the superior mesenteric artery (Fig. 90). Their blood returns through the colic veins and superior mesenteric to the portal veins, and pylephlebitis along this avenue gives rise to abscesses of the liver following dysenteric ulcerations of the large intestine.

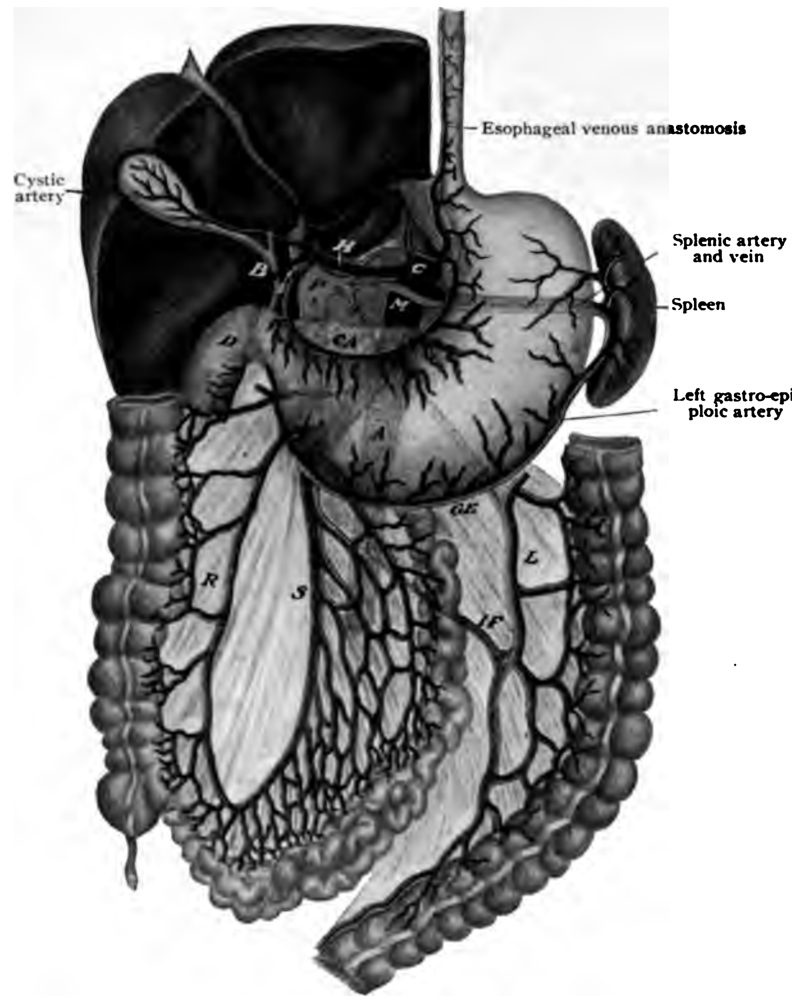


Fig. 90.—Blood-supply of abdominal viscera (modified from Joessl). B, Common bile-duct. The arrow upon its right (to left in body) shows the course of the blood flowing back from the right coronary vein into the portal vein. P, Portal vein. H, Hepatic artery. C, Celiac axis. The white arrow seen between H and C indicates the blood returning from the left coronary into the splenic vein. M, Placed just above origin of superior mesenteric artery, which supplies the ascending colon, transverse colon through the colic arteries (R), and all of the small intestine except the duodenum through the mesenteric vessels (S). A, Aorta, between inferior and superior mesenteric vessels. IF, Inferior mesenteric artery, supplying the descending iliac and pelvic colon and greater portion of the rectum. Accompanying R, S, and L can be seen the corresponding veins (colic, superior and inferior mesenteric) which return the blood (along the paths indicated by the black arrows above the lesser curvature of the stomach) into P, the portal vein. CA, Right and left coronary arteries. D, Gastroduodenal artery, which divides into the superior pancreaticoduodenal and the right gastro-epiploic artery. GE, Gastro-epiploic arteries and veins.

When an **artificial anus** is established, the point of preference is usually the iliac colon. At times, in cases of intestinal obstruction, it becomes necessary to establish the opening at a higher point. Care should be taken, however, to open the bowel at as low a point as possible, otherwise the patient will starve through lack of absorption, especially if the lower portion of the ileum is involved. The large intestine can be readily distinguished from the small intestine by its longitudinal muscular bands, and the haustra or bulging portions of the intestine between these bands (Fig. 81). At the end of the anterior longitudinal band of the ascending colon and cecum the appendix is usually found. The blood of the lower portion of the descending, iliac, and pelvic colon is returned by the inferior mesenteric vein (Fig. 90). The nerves are derived from the inferior and superior mesenteric plexuses (Fig.104).

On account of the close proximity of the small intestines to the anterior abdominal wall, they are not infrequently injured in contusions of the viscera without external wounds. These usually affect the ileum, or the jejunum close to the duodenojejunal flexure, where the intestine is fixed. In the majority of instances the intestine is perforated through direct action of the force, being caught between the spinal column, as will be readily understood from a reference to figure 88, and the abdominal wall, by a horse-kick, fall upon a blunt object, etc. At the lower portion of the ileum are situated the solitary follicles and Peyer's patches, so that typhoid perforations are most frequently found close to the ileocecal valve.

In the above description, the suggestion made by Jonnesco has been followed in calling that portion of the colon which lies in the iliac fossa the *iliac colon*, and that portion which lies in the pelvis the *pelvic colon*. The iliac colon includes the portion of the sigmoid flexure which extends from the crest of the ilium to the brim of the pelvis. The pelvic colon embraces the remainder of the sigmoid colon and the first part of the rectum of the old descriptions. This has a long mesentery and forms a large loop lying in the pelvic cavity. It ends at the third sacral vertebra in the rectum proper. The latter will be described in its topographic relations to the other viscera of the male and female pelvis. (See below.)

## The Spleen.

The spleen lies deeply in the left hypochondriac region, between the stomach and the diaphragm. Its outer or diaphragmatic surface rests upon the back part of the diaphragm, being separated from the chest-wall by the diaphragm and the costo-diaphragmatic reflection of the

pleura (see Fig. 51) as well as the lower margin of the left lower lobe of the lung. Its upper end reaches the tenth dorsal vertebra; its anterior border seldom reaches beyond the costo-clavicular line (a line drawn from the sterno-clavicular joint to the tip of the tenth rib), though occasionally it extends to the mid-axillary line. Its inner surface is in relation to the fundus of the stomach, and at this point the hilus of the organ is situated, where the splenic artery, a branch of the celiac axis (see Figs. 74 and 90), enters. The splenic vein passes parallel with the artery to enter the portal (see Fig. 90) vein.

In addition to being in contact with the stomach, the spleen is also in close relation, by its inner surface, to the kidney and splenic flexure of the colon. The anterior border points downward and is usually notched, so that when the spleen is enlarged and projects below the left costal arch, this notched border is a means of identification of the organ.

The upper portion of the spleen with the fundus of the stomach and left lobe of the liver (see Figs. 68 and 69) occupy the left subphrenic space, so that abscesses of the spleen often rupture into this space, or, on account of the relation of the spleen to the stomach and splenic flexure of the colon, the abscesses may rupture into either of these viscera, or into the left pleural cavity. The spleen is entirely surrounded by peritoneum. It is rather imperfectly held in place, its best means of fixation being a ligament by which it is attached to the diaphragm—the phrenosplenic. It is also attached to the stomach by the gastrosplenic omentum and to the colon by the phrenocolic ligament. The spleen rests upon the latter.

The long axis of the spleen corresponds to the course of the tenth rib, and upon the surface of the bony thorax it extends from the ninth to the eleventh ribs and from the above-mentioned costo-clavicular or mid-axillary line backward to the spine.

The spleen moves with respiration, but its respiratory mobility is less than that of the liver. Fluid in the left pleural cavity pushes the spleen downward. On account of the lax fixation of the spleen, it may migrate to almost any portion of the abdominal cavity, and cases have been reported where enlargements in the right iliac region, and even in the pelvis, have been found to be due to a wandering spleen. In order to fix the spleen (splenopexy), an incision is made along the left border of the left rectus, and it is attached as close as possible along the line of the phrenosplenic ligament, or at times it is placed in a slit in the abdominal muscles.

Abscesses of the spleen, of embolic origin, occur in pyemia. The spleen is at times enormously enlarged. During malaria, in one of the forms of leukemia, and in tumors of the spleen it may be so large as to

occupy the entire left half of the abdominal cavity. It can usually be recognized by its crenated or notched edge.

A large number of cases of subcutaneous rupture of the spleen have been reported. These have occurred through a crushing force in which the spleen was caught between the force and the spinal column on account of the yielding character of the lower ribs.

## The Pancreas.

The pancreas is an elongated, glandular mass lying behind the stomach at the level of the first and second lumbar vertebræ. In thin subjects, especially in old age, it may be felt through the anterior abdominal wall as a horizontal thickening above the umbilicus, simulating a neoplasm.

Its **head** is surrounded by the vertical and ascending portions of the duodenum, the common bile-duct lying between the bowel and the head of the pancreas (see Figs. 73, 74, and 91); behind it lie the vena cava and aorta (see Fig. 90). The neck joins the head with the body. On its posterior surface lies the portal vein. The body and its termination, called the **tail,** are 10 to 12 cm. (4 to 5 inches) long. Its anterior surface is covered (see Fig. 82) by the peritoneum of the lesser peritoneal cavity and is in relation with the posterior wall of the stomach. The inferior surface rests upon the duodenojejunal flexure and transverse colon, just before passing into the splenic flexure (Fig. 83).

Its posterior surface is firmly adherent to the aorta, left renal vessels, and left kidney. The splenic artery runs along this surface close to its upper edge. The organ normally possesses two ducts, which may open separately into the duodenum. The main duct joins near the head with the common bile-duct, and opens with it into the duodenum (Fig. 91), the accessory duct opens a little higher up.

Calculi form in these ducts, giving rise to colic resembling that of gallstones, with fat diarrhea and diabetes. The effect of a carcinoma of the head has been described under the duodenum. It has been found that the escape of the secretion of the pancreas into the retroperitoneal connective tissue or upon the surface of the peritoneum will cause a fat necrosis. Cysts of the pancreas not infrequently develop after abdominal injuries, or even spontaneously, as a result of inflammations of the pancreas. They either push forward toward the anterior abdominal wall in the lesser peritoneal cavity between the stomach and liver, or between the stomach and transverse colon. A less frequent development is between the layers of the transverse mesocolon.

The functions of the pancreas are that it has some relation to diabetes,

total extirpation of the organ causing genuine glycosuria. Even tumors like carcinoma will cause diabetes. It also assists in digesting fats and albumins, so that if, in addition to sugar in the urine, there is evidence of free fat in the feces and of imperfect digestion of albumins, there should be a strong suspicion of pancreatic disease.

### The Kidneys.

The kidneys lie on either side of the spinal column, extending from the upper border of the twelfth dorsal vertebra to the lower border of the second lumbar (Figs. 81 and 100, or even to the middle of the third; that is, externally they extend from the spine of the eleventh dorsal to that of the second lumbar vertebra (Figs. 50 and 69). The right kidney is generally about one finger's breadth lower than the left. They usually lie lateral to the transverse processes, but they may approach the bodies of the vertebræ, and even lie upon them. The posterior surface rests upon the quadratus lumborum (see Figs. 83 and 84) at its inner edge, the outer edge of the kidney resting upon the transversalis muscle, being separated from the skin by the latissimus dorsi and lumbodorsal fascia of the transversalis muscle.

The relations of the upper pole of each kidney are of great practical value. Under normal conditions the reflection of the pleura corresponds to a line drawn from the body of the twelfth dorsal vertebra and crossing the twelfth rib at about its middle (Fig. 50). According to Luschka, it is still lower, touching the tip of the twelfth rib. The twelfth rib is occasionally very short, or absent. It is always best, before performing any operation upon the kidney with a view to removal of the same, to count the free edges of the last two ribs in order to determine if the twelfth is absent, on account of the danger of opening the pleural cavities.

In this manner the upper pole of the right kidney, as well as the suprarenal capsule, which lies upon it at this point, are close to the complementary sinus of the pleura. Hence abscesses of the kidney may perforate into the pleural cavity and cause an empyema.

Both kidneys are inclosed in a fibrous capsule, which is thin, and may be readily stripped from the parenchyma. It has been proposed of late to remove this capsule in order to relieve the congestion due to acute and chronic inflammations of the kidney.

Adherent to the fibrous capsule by numerous frail bundles of connective tissue is the fatty capsule. It is not present, generally, up to the tenth year, and disappears with general emaciation.

A third capsule has been described by Gerota, called the renal or perinephric fascia, lying outside of the fatty capsule. Its anterior layer

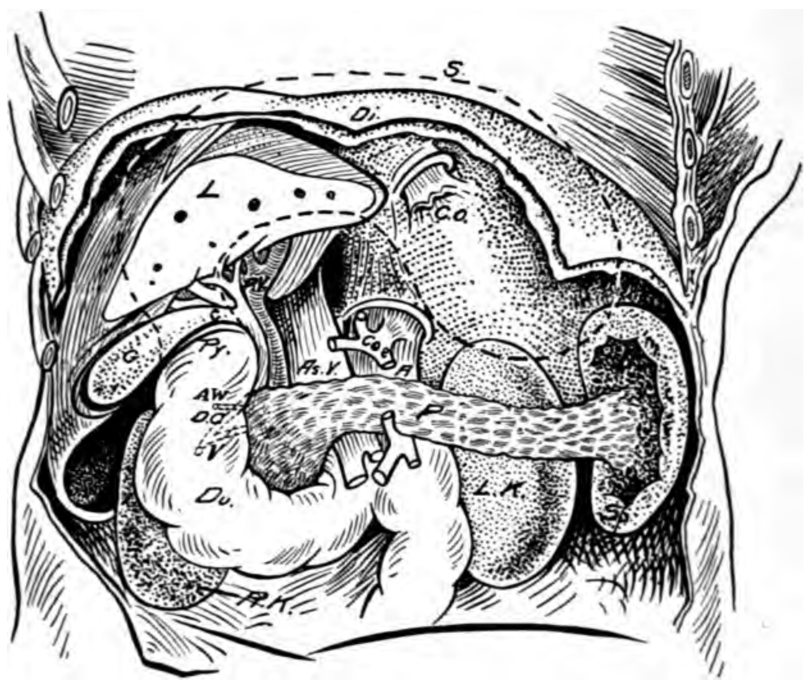


Fig. 91.—Topographical relations of liver, bile-passages, duodenum, pancreas, and kidneys. S, Stomach, shown in dotted outline, pulled upward. L, Cut edge of right lobe of liver. P.V., Portal vein. As.V., Ascending vena cava. D.C., Common duct, shown in dotted outline, as it passes through the wall of the duodenum. G., Gall-bladder. The cystic duct joins with the hepatic duct to form the common duct lying to the right of the portal vein. Du., Duodenum. Sp., Spleen. R.K., Right kidney. L.K., Left kidney. Coe., Celiac axis. A., Aorta. C.O., Cardiac orifice of stomach. Di., Diaphragm. P. Pancreas. Py., Pyloric end of stomach. V., Duct of Wirsung joining with common bile-duct. A.W., Accessory duct of Wirsung.

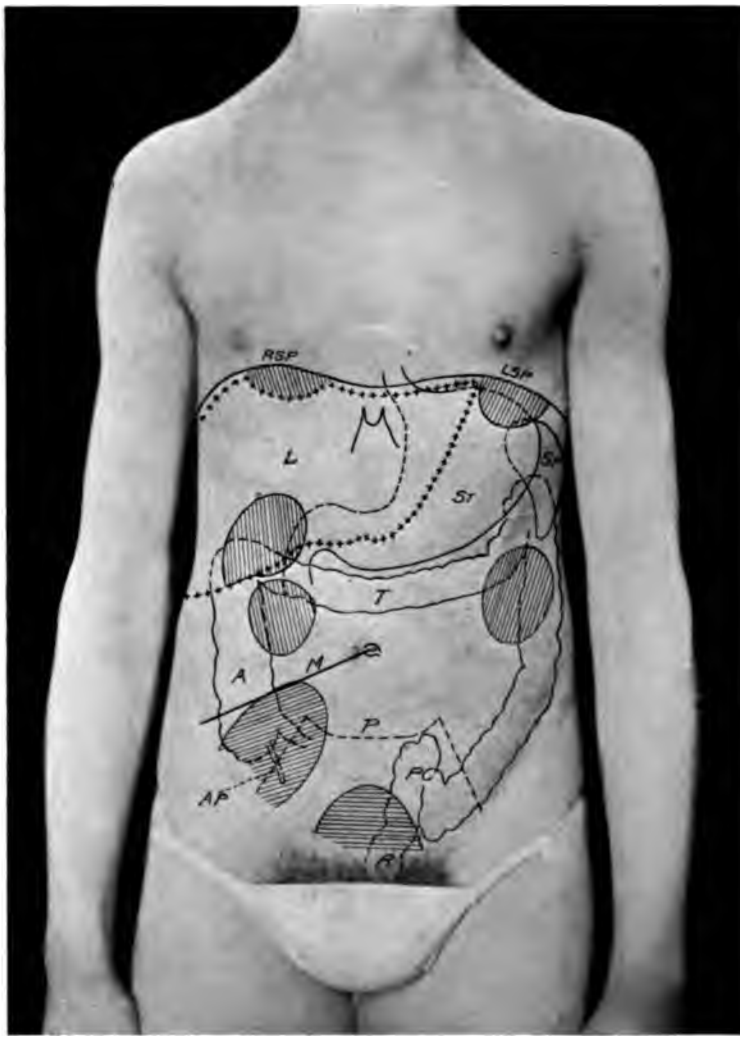


Fig. 92.—Most frequent location of post-appendiceal abscesses. AP, Appendix. M, McBurney's line. A, Ascending colon. T, Transverse colon. L, Liver. St, Stomach. Sp, Spleen. RSP, Right subphrenic abscess. LSP, Left subphrenic abscess. PC, Pelvic colon. R, Rectum.

passes across the front of the kidney and meets the same layer of the opposite kidney. The posterior layer is attached to the periosteum of the vertebræ. This fascia is adherent anteriorly to the peritoneum.

The renal vessels and ureter enter the kidney at the pelvis, and are its chief support, the various capsules being uncertain and insecure supports.

A mobility of an inch of either kidney is not considered abnormal in an inward, upward, or downward direction, but the kidney is prevented from moving outward by a normal arrangement of the perinephric fascia. The degrees of abnormal mobility (Morris) are:

1. When the kidney moves up and down so that the lower half comes between the two fingers during inspiration.

2. When the greater part, or even the whole, of the kidney can be grasped during a deep inspiration, but ascends again during expiration.

3. When the whole kidney descends below the examiner's fingers and can be retained below them after the patient makes a full expiration.

The kidneys lie rather obliquely in the abdomen; the outer border is directed somewhat upward and backward, the inner, downward and forward (Fig. 81). The hilum of the left kidney is two inches from the aorta; the hilum of the right is about $1\frac{3}{4}$ inches from the vena cava. Both kidneys lie behind the peritoneum, being separated from it by a considerable amount of loose, areolar, subperitoneal tissue (Figs. 81 and 102). On the right side the lower third is free, not being covered by peritoneum. The right kidney is in relation on its anterior surface, in its upper two-thirds, with the liver; its lower third with the hepatic flexure of the colon, and its inner edge is adherent to the duodenum. It is very firmly connected with the colon, so that perinephric abscesses not infrequently rupture into this. At its upper pole lies the suprarenal capsule between the kidney and liver. The upper third of the left kidney is separated from the fundus of the stomach by the splenic artery; its middle third is in contact with the pancreas; its lower third is covered by parietal peritoneum (Fig. 69). The external border of this kidney is in contact, in the upper two-thirds of its extent, with the spleen, and in the lower third with the descending colon.

The suprarenal capsule is loosely connected with each kidney in the upper pole, being contained within the layers of the perinephric fascia. At the pelvis of the kidney each renal artery divides into three chief branches, which sink into the sinus behind the corresponding branches of the renal vein. The renal vein is a short, wide vessel and forms one of the principal supports of the kidney; its primary branches, four or five in number, issue from the hilum in front of the branches

of the artery until it joins the vena cava. The left vein is longer than the right (see Figs. 80 and 100). The left renal vein is joined by the left spermatic vein. The renal artery above it at the hilum gives one or two small branches to the suprarenal body and to the ureter. The renal vein also receives branches after leaving the hilum.

The kidney may be congenitally displaced, being usually found in the iliac fossa at the entrance of the true pelvis, or at the promontory, or even further in the pelvis, even in front of the rectum. The author observed a case at autopsy in which the latter position was a cause of difficult labor. If one of the kidneys is missing, the other is usually in its normal position.

## The Ureter.

The ureter begins at the pelvis of the kidney, and at this point renal calculi are apt to lodge, although they may be so large as to form a complete cast of the kidney, extending up into the calyces. At the point where the pelvis passes over into the ureter, there is a sudden narrowing of the caliber, and strictures of the ureter are not infrequently situated here.

The ureter descends from a point just above the lower extremity of the kidney (see Fig. 72) (lying upon the psoas muscles [see Figs. 86, 89, and 100] and behind the peritoneum) to the brim of the pelvis. At this point it crosses the lower end of the common iliac artery, and turns abruptly backward and outward on the side wall of the pelvis to a point about an inch in front of the spine of the ischium; thence it passes forward and inward on the upper surface of the levator ani to its termination at the base of the bladder. That portion of the ureter which lies above the brim of the pelvis is called the abdominal portion, and is about five inches in length. The portion between the brim of the pelvis and the bladder is called the pelvic portion. Its relation to the male and female genitalia will be described under "The Pelvis."

The average length of the ureter is about 30 cm. (12 inches), the left being slightly longer than the right on account of the higher position of the left kidney. The diameter of the ureter is not uniform; it presents three contractions and two intermediate dilatations. The first contraction is the narrowest portion of the ureter (Fig. 81), and is situated about 7 cm. ($2\frac{1}{2}$ inches) below the hilum of the kidney. The second contraction, called the inferior isthmus, is at the angular bend at the foot of the pelvis, and the third contraction is at its termination in the bladder-wall. The two dilatations which lie between the three contractions are frequently called the upper and the lower spindles.


Fig. 93.—Specimen illustrating one of the causes of imperforate anus. S, Sigmoid flexure and descending colon, terminating in a blind pouch (R), corresponding to the rectum, which communicated by a slit-like opening with B, rudimentary bladder. K, Kidney. U, Dilated ureter. C, Clitoris. A, Dilated hollow viscus, communicating through a wide opening with B, bladder, and probably corresponding to the dilated urachus.

The former lies in the abdomen, the latter in the pelvis. The ureters converge as they descend in the abdomen.

## The Pelvis in General.

The pelvis is formed by the innominate bones and the sacrum. It is divided into the false pelvis, lying above the iliopectineal lines, and the true pelvis, lying below them. The false pelvis was taken up in connection with the iliac fasciæ. The true pelvis has an inlet, or superior aperture, which is cordate in the male and more oval in the female. The true pelvis also has an outlet or inferior aperture. Of clinical interest in the inlet is the anteroposterior or conjugate diameter, which is of great use in obstetrics as an index to the size of the pelvis, and also the oblique diameters, taken from the sacro-iliac joint of one side to the iliopectineal eminence of the other. The transverse diameter of the inlet is taken across the point of greatest width.

The position of the pelvis in the living, when the figure is erect, may be approximately represented by placing it so that the anterior superior iliac spines and the symphysis pubis lie in the same vertical plane. On an average it forms an angle of from 50 to 60 degrees with the horizon.

The outlet of the pelvis has as its boundaries the pubic arch, rami of the ischium, the tuberosities of the ischium, and the coccyx.

In the same manner as was seen in the case of the bony thorax, the pelvis may be changed in its diameters as the result of joint or local diseases. Of the general diseases, those most frequently affecting it are osteomalacia and rickets. Among the local conditions are unilateral or bilateral congenital dislocation of the hip (see Fig. 143), or those due to disease of the vertebræ or hip-joint, or to injury or disease of the pelvic bones.

The most important joint in connection with the pelvis is the **sacro-iliac joint** (see Fig. 88). Externally, the posterior superior spine of the ilium corresponds to the middle of this joint. The capsule of the joint is formed by ligaments which lie in front and back of it and the synovial cavity is very imperfect and rudimentary. It is frequently the seat of tubercular infection.

Just below, and to its outer side in the pelvis, lies the great sacro-sciatic notch, through which the principal branches of the sacral plexus which go to form the sciatic nerve pass, so that these nerves are in close proximity to the joint.

The **pelvic fascia** is a continuation of the iliac fascia; it lines the pelvic wall. From its outer surface arises, behind, the pyriformis muscle, and at the sides of the pelvis the obturator internus (see Figs. 88 and 103).

Between the back of the pubis and the spine of the ischium, to both of which the pelvic fascia is attached, extends a thickened band of the fascia, called the white line. It gives origin to the fibers of the levator ani muscle (see Fig. 101) and sends off a visceral layer which arches downward and inward and crosses the floor of the pelvis to support the pelvic viscera.

The internal iliac vessels and their branches lie on the inner aspect of the pelvic fascia, the sacral plexus lies on its outer aspect. In the female the pelvic fascia, instead of inclosing the prostate gland, incloses the neck of the bladder and the vagina. It also invests the lower part of the uterus instead of the seminal vesicles. Any suppuration from the pelvic organs, prostate, bladder, rectum, etc., which escapes beneath the visceral layer of the pelvic fascia, will be limited in its course upward by the attachment of the levator ani, whereas any suppuration above this layer can readily escape to the subperitoneal connective tissue and spread in all directions. On account of the attachment of the parietal layer of the pelvic fascia to the sides of the pelvis, pus migrating downward from the abdominal cavity will be limited in its spread by the attachments of this fascia, unless it breaks through it, when it can pass to the perineum.

## Relations of Pelvic Viscera.

The best idea of the relations of the pelvic organs in the male and female, to each other and to the walls of the pelvis, can be obtained by a study of sections made in various directions, as well as a view from above and below of the pelvic organs lying in their normal relations. For the **male pelvis** an inspection of figures 79, 81, 94, 98, and 103 is suggested.

The **bladder** in the male, when empty, lies immediately behind the symphysis pubis (Fig. 94) and has the form of an inverted tetrahedron. The base of the triangle, or superior surface of the bladder, faces the general peritoneal cavity, and its apex corresponds to the orifice of the urethra. The bladder is firmly held in place on its anterior aspect by the puboprostatic ligaments running to the sides of the pelvis, and the ligament (U in figure 79), called the anterior ligament, which contains the remains of the urachus. The upper portion of the bladder has the ability to change its shape as the bladder becomes fuller. In doing so it raises the fold of peritoneum (PE in Figs. 81 and 94), so that when the bladder is fully distended, this reflection of peritoneum is raised a distance of 1½ to 2 inches above the upper margin of the pubis, and access can be had to the bladder without entering the peritoneal cavity. This anatomic fact is utilized in the operation

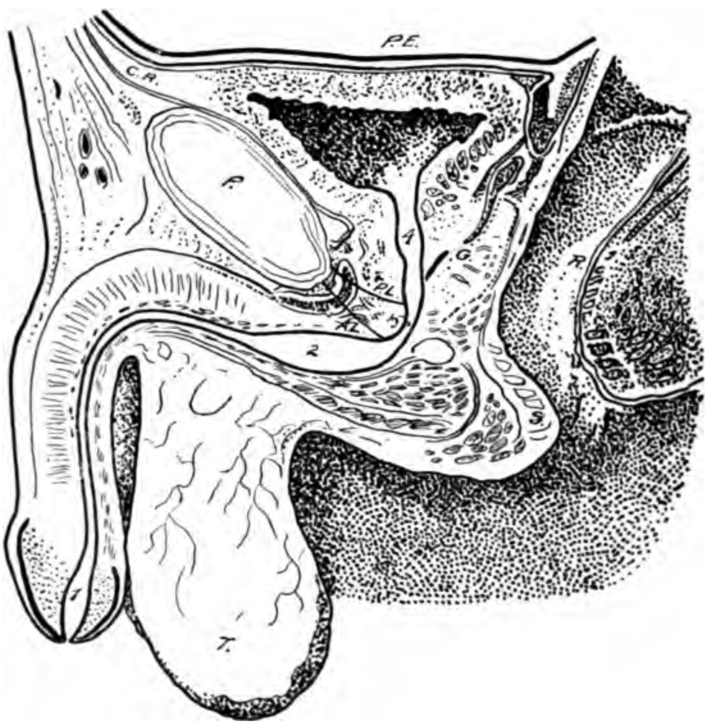


Fig. 94.—Sagittal section of pelvis showing widths of different portions of the urethra, and the relation of the structures at the base of the bladder to the rectum. 1 Fossa navicularis. 2, Bulbous portion of urethra. 3, Membranous portion of urethra. 4, Prostatic portion of urethra (note its direction), ending in the bladder. C.R, Connective-tissue space between peritoneum and abdominal wall. P.E., Peritoneum covering superior surface of bladder. G., Prostate gland. R., Rectum. S., External sphincter. P., Pubic arch. T., Median raphé of scrotum, separating the testes. A.L., Anterior layer triangular ligament. P.L., Posterior layer triangular ligament.

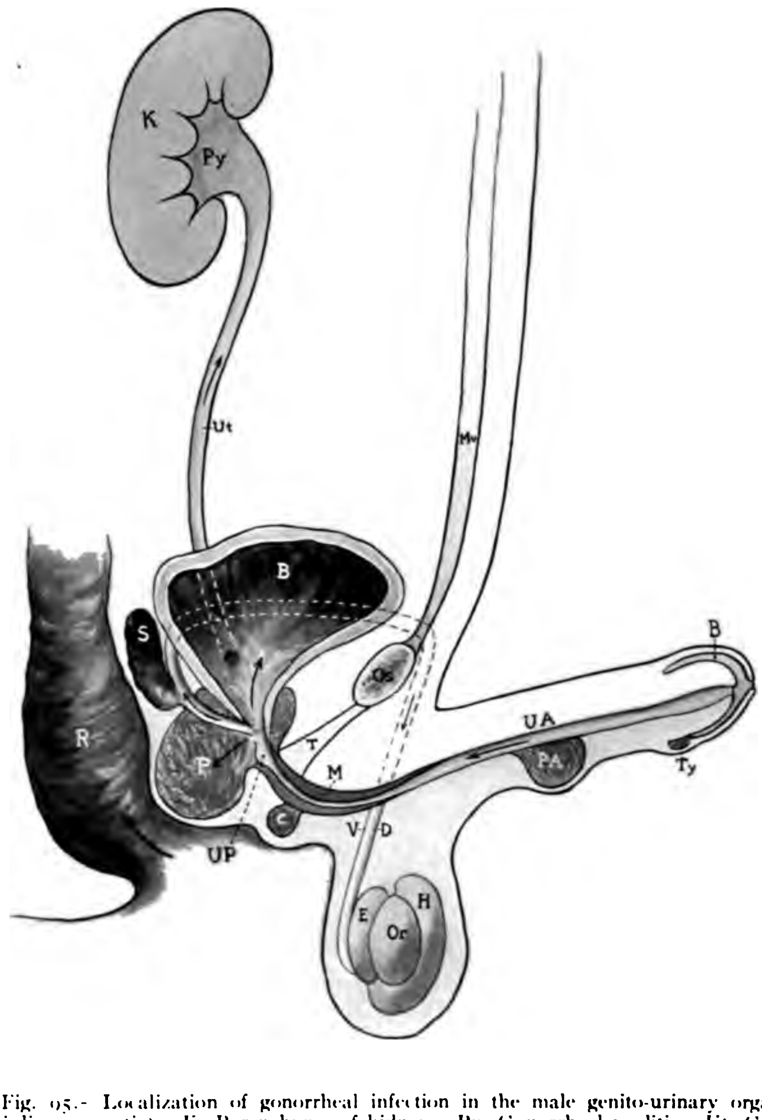


Fig. 95.- Localization of gonorrheal infection in the male genito-urinary organs (semi-diagrammatic). K, Parenchyma of kidney. Py, Gonorrheal pyelitis. Ut, Gonorrheal ureteritis. The arrow points the direction in which the infection ascends from the bladder to the kidney. B, Bladder wall. The arrow at the neck of the bladder indicates the direction of the infection from the urethra to the bladder (gonorrheal cystitis). UP, Seat of posterior urethritis. M, Infiltration of urethral walls at bulbo-membranous junction most frequent seat of gonorrheal stricture. UA, Anterior urethra. T, Triangular ligament, which divides the urethra into the anterior and posterior portions. Os, Symphysis pubis, from which triangular ligament is suspended. PA, Periurethral abscess. B, Balano-posthitis. Ty, Inflammation of Tyson's gland. P, Seat of prostatic abscess, pointing toward the perineum, involving bulging of the anterior wall of the rectum. R, Rectum. The arrow shows the direction in which infection occurs, causing a gonorrheal proctitis. V D, Seat of the vas deferentitis. E, seat of gonorrheal epididymitis. Or, Orchis, or body of testis. H, Seat of acute gonorrheal hydrocele. Mu, Musculature of abdominal wall. S, Seminal vesicles, the seat of gonorrheal vesiculitis. The arrow shows how transmission is effected from the posterior urethra to the seminal vesicles and vas deferens, from the latter to the epididymis, etc.

known as suprapubic cystotomy. Even when the bladder is full and rises out of the pelvis, the base or lower portion of the bladder remains stationary and in its normal relation to the rectum and the structures at its base. The peritoneum (Figs. 79, 81, and 94), after covering the superior surface of the bladder, makes a slight downward dip between the bladder and the rectum, and then covers the anterior and a portion of the lateral surfaces of the rectum. When the bladder is full, this rectovesical pouch, as it is called, becomes relatively deeper. The superior surface of the bladder has lying upon it coils of the ileum and pelvic colon. The posterior surface of the bladder is in contact with the ampulla of the rectum, being separated from it only (see Figs. 94 and 96) by loose cellular tissue, the levatores ani muscles, and below by the internal sphincter and the structures at the base of the bladder. These structures at the base of the bladder are the seminal vesicles (well shown in Fig. 96) and the terminations of the vasa deferentia on each side.

Laterally, in contact with the side of the bladder, is the **ureter** (see U in Figs. 81 and 96), which, after crossing the pelvic brim in the male, passes downward and backward along the side wall of the pelvis to a point about one inch to an inch and a half in front of the spine of the ischium, lying immediately in front of the internal iliac artery. The ureter, before reaching the bladder, is covered by peritoneum, which separates it from the pelvic colon on the left, and from the terminal portion of the ileum on the right. It runs forward and inward from the side wall of the pelvis, lying upon the upper surface of the levator ani on each side. Before it reaches the bladder it is crossed in front by the vas deferens, which passes between it and the side wall of the bladder, and it enters the bladder wall immediately in front of the upper end of the seminal vesicle (see Figs. 81 and 94).

Ordinarily the bladder holds from six to ten ounces in the adult male, but it may contain one pint.

The mucous membrane of the bladder is continuous with that of the ureters and of the urethra. The ureters pass obliquely through the bladder wall, so that when the bladder is full, it closes the openings of the ureters and prevents further access of urine. The internal orifice of the urethra is situated immediately beneath the pubis. When the bladder is empty, this orifice corresponds to the apex of the inverted tetrahedron which the empty bladder forms. It does not change its position when the bladder is full, being quite firmly fixed by the puboprostatic ligaments to the pubes. The superior part of the bladder is usually called the *fundus;* that portion of the

bladder which faces the rectum and structures between the bladder and rectum is called the *base*, and where the bladder suddenly narrows to form the internal orifice of the urethra is called the *neck*. The mucous membrane of the bladder is only loosely connected to the underlying muscle.

At the base of the bladder the mucosa is firmly attached over a triangular area known as the *trigone*, whose apex corresponds to the internal orifice of the urethra, and the angles of the base correspond to the orifices of the ureters. The minute opening of each ureter has an elliptical outline. The sides of the trigone form an approximate equilateral triangle, each of the sides being about one inch in length.

On account of its well-protected position behind the pubes, the bladder when empty is seldom exposed to injury, except in fractures of the pelvis, when it may be punctured by one of the fragments. When full, the bladder is far more subject to injury, being then, to some extent, an abdominal organ. In children the bladder always rises out of the pelvis when full. (See Fig. 25.) A rupture of the bladder may occur, independent of any fracture. If at the fundus of the bladder or close to the rectovesical pouch, the urine escapes into the general peritoneal cavity; if at the base or anterior or lateral surface below the reflection of the peritoneum, it escapes into the loose cellular tissue (see Fig. 103) between the peritoneum and pelvic fascia. Hence the latter (extraperitoneal rupture) gives rise to a smaller mortality than the former (intraperitoneal rupture).

In enlarged conditions of the prostate the base of the bladder may be elevated just behind the urethral orifice and cause the musculature to be greatly hypertrophied, the mucous membrane often bulging between the trabeculæ, or ridges formed by the hypertrophied muscle. Such diverticula may be punctured through the careless use of instruments in the aged. At the base of the bladder a pouch forms behind the hypertrophied prostate in which a portion of the urine lies and cannot be expelled. This urine which is left behind at each urination is called *residual urine*, and it readily decomposes, giving rise to an inflammation of the bladder, or cystitis. All forms of cystitis may, through migration of the organisms along the ureters into the pelvis of the kidney, give rise to a condition known as pyelonephritis, formerly called surgical kidney, the effect upon the system being that of an acute or chronic toxemia, called urosepsis.

The **seminal vesicles and vasa deferentia** are covered by peritoneum close to the entrance of the ureters into the bladder. They


Fig. 96.—Dissection of base of male bladder. B, Bladder. D, Vas deferens. U, Ureters. Upon the right side the ureter is seen to disappear obliquely through the coats of the bladder, a little above the upper end of the seminal vesicles (SV). Upon the left side its entrance through the bladder-wall is concealed by the upper end of the seminal vesicle. SV, Seminal vesicle. P, Prostate gland, showing lateral lobes. M, Membranous portion of urethra. T, Anterior layer of triangular ligament. I, Ascending ramus of ischium and descending ramus of pubes.

converge toward the median line and their ducts enter the prostatic portion of the urethra on either side of the median line, so that in removal of the prostate an injury of the ducts is almost unavoidable.

Around the neck of the bladder there is a rich plexus of veins known as the prostatic plexus, which frequently become so congested as to become varicose, giving rise to either spontaneous hemorrhages into the bladder or to severe bleeding during catheterization, especially in the aged.

The **male urethra,** from the internal orifice at the bladder, called the internal meatus, to the external meatus, measures about eight inches in length, and is divided (from the bladder outward) into three portions —a prostatic, a membranous, and a pendulous or spongy. The first part, or prostatic, lies within the pelvic cavity and has an almost vertical course (see Fig. 94) as it traverses the prostate. The **prostatic portion** has opening into it the orifices of numerous prostatic glands on each side of a median ridge or elevation in its floor or posterior wall. On each side of a little depression in this ridge (prostatic utricle) open the ejaculatory ducts. The **membranous portion** of the urethra lies between the deep or posterior and the superficial or anterior layer of the triangular ligament (see Figs. 94 and 96). It is surrounded by the fibers of the compressor urethræ muscle, which also lies between the folds of the ligament, and by Cowper's glands (see Figs. 94 and 97). This portion of the urethra leads downward and forward to the third or pendulous portion. The membranous portion is the most fixed part of the urethra, and in falls upon the perineum, or in fractures of the pelvis, especially of the symphysis pubis, it is most likely to be either partly or completely ruptured. The **spongy,** often called the **pendulous portion** of the urethra, is surrounded throughout its whole extent by the erectile tissue of the corpus spongiosum. When the penis is in contact with the scrotum, the bulbous or proximal dilated end of the pendulous urethra looks upward and forward, the remainder of the pedulous urethra (see Fig. 94) downward and forward. In order to catheterize or to pass sounds, it is necessary to bear in mind the curve of the urethra. In passing such an instrument, the penis should be at first held upward so that the entire length of the pendulous portion looks upward and forward. As soon as the instrument meets with resistance (anterior layer of triangular ligament) the instrument and penis should be lowered so that the tip of the instrument can follow the almost vertical upward course of the membranous and prostatic portions of the urethra. These instructions will be readily understood by a reference to Fig. 94.

Clinically, the urethra is divided into two parts, the **anterior portion** extending from the external meatus to the anterior layer of the triangular ligament—that is, where one first meets with a resistance due to the spasmodic contraction of the compressor urethræ muscle lying between the layers of the triangular ligament; the second portion is the **posterior portion,** which embraces the membranous and prostatic portions of the urethra. In gonorrheal inflammation it is important to bear this distinction in mind, as many cases are limited to the anterior portion; others extend over both anterior and posterior portions of the urethra.

The mucous membrane lining the pendulous portion contains a large number of glands or crypts called the glands of Littré, as well as the orifices into the bulbous portion of the glands of Cowper, referred to above.

The prostatic portion of the urethra is about $1\frac{1}{4}$ to $1\frac{1}{2}$ inches in length; that of the membranous portion, $\frac{3}{4}$ of an inch to 1 inch, and of the penile or pendulous portion $6\frac{1}{2}$ inches, making an average total length of $8\frac{1}{2}$ inches. As will be seen by a reference to figure 94, the caliber of the urethra varies in its different portions, being widest in the bulbous portion and at the fossa navicularis, and narrowest at the external meatus and membranous portion.

The size of steel sound which the normal urethra admits is as follows:

| | | |
|---|---|---|
| 1. Meatus urinarius | 21 to 28 | French. |
| 2. Fossa navicularis | 30 to 33 | " |
| 3. Middle of pendulous portion | 27 to 30 | " |
| 4. Bulbous portion | 33 to 36 | " |
| 5. Membranous portion | 27 | " |
| 6. Apex of prostatic portion | 30 | " |
| 7. Middle of prostatic portion | 45 | " |
| 8. Base of prostatic portion | 33 | " |

From the anatomy of the urethra, the complications of gonorrhea can be readily understood. Infiltration of the mucous membrane and cicatrization of the infiltrated area, with subsequent narrowing of the canal, may exist at any portion, but is most frequent at the junction of the bulbous (end of spongy) and membranous portions of the urethra. It is extremely rare in the prostatic portion of the urethra. The inflammation may invade the many glands of Littré and cause casts of the same to be present in the urine in the form of so-called "clap shreds." The fact that the prostatic glands and the orifices of the ejaculatory ducts open into the prostatic portion of the urethra will explain a fre-

quent complication in the form of an inflammation of the prostate, even leading to abscess of the same. It also explains an inflammation of the seminal vesicles, vasa deferentia, and their continuation into the epididymis and testis of each side (see Figs. 81, 94, and 96). (Acute or chronic gonorrheal prostatitis, vesiculitis, deferentitis, cystitis, and epididymitis.) The infection may even extend into the ureter and to the kidney (gonorrheal ureteritis and pyelitis).

The **prostate gland** is a partly glandular and partly muscular organ, surrounding the beginning of the male urethra. It lies within the pelvis inclosed in a dense capsule derived from the pelvic fascia. Its size varies greatly, being usually $1\frac{1}{4}$ to $1\frac{1}{2}$ inches in length, the antero-posterior diameter $\frac{3}{4}$ of an inch, and the vertical diameter about $1\frac{1}{4}$ inches (see Figs. 94 and 96). The apex of the prostate is directed downward and its base is directed upward against the under aspect of the neck of the bladder, being continuous with the bladder-wall. The lateral surfaces of the prostate are convex and prominent (see Fig. 96), the posterior surface is separated from the anterior wall of the rectum by a layer of pelvic fascia. The prostate is penetrated by the urethra and the ejaculatory ducts. That portion of the prostate which lies between the ducts and the posterior aspect of the urethra is called the middle lobe; in old age it may enlarge to such an extent as to be the chief source of obstruction in hypertrophied prostate, forming a valve-like opening in front of the internal orifice of the urethra which prevents urine from escaping. It then causes a considerable elevation in the median line of the bladder. The greater portion of the prostate is composed of two lateral lobes (see Fig. 96) separated by an indistinct groove. These lobes are frequent seats of hypertrophy. When they are enlarged, the course of the prostatic portion of the urethra may be either to the left or right of the median line and greatly elongated, according to which side is enlarged. When both lobes are enlarged, the prostatic portion of the urethra is not only lengthened so that the total length of the urethra may reach ten inches, but the enlarged prostate forms an almost absolute obstruction to the exit of urine. When the middle and lateral lobes of the prostate are all enlarged, the prostatic portion of the urethra may divide at the middle lobe, one groove running to each side of it.

The prostate is surrounded by a large plexus of veins, called the prostatic plexus, into which the veins of the penis open, which empty into the vesical plexus of veins.

The **vas deferens,** if followed from the base of the bladder, on either

side, lies extraperitoneally during its entire course to the internal abdominal ring (see Figs. 79 and 81). Its entire length is about eighteen inches, but the actual distance traversed by it is not more than twelve inches. From the base of the bladder it passes upward to the side wall of the pelvis (see Figs. 79, 81, and 96). After crossing the pelvic brim it unites along the inner side of the iliac vessels with the spermatic vessels.

These structures and the accompanying nerves and loose coverings derived from certain layers of the abdominal wall (infundibuliform fascia and cremaster muscle) from the spermatic cord.

The **spermatic cord** passes through the inguinal canal on either side (see Figs. 79 and 81), entering the scrotum at the external abdominal ring. It can be readily detected during life by its hard, firm, cord-like feeling when it is held between the fingers and thumb. The spermatic cord always lies behind and to the outer side of an inguinal hernia sac.

The vas deferens at its lower end joins with the **seminal vesicles,** which are intimately related to the wall of the bladder, being separated at the upper ends by the rectovesical pouch of peritoneum. They serve as reservoirs for the testicular secretion.

At its outer or scrotal end the spermatic cord ends in the **epididymis.** This latter structure sits like a cap upon the posterior part of the outer surface of the testis. Its upper portion is called the *globus major*, or head of the epididymis. The lower and smaller end, into which the vas deferens enters, is called the tail, or *globus minor*. The intervening part is called the body of the epididymis.

The **testis,** like the epididymis and the extra-abdominal portion of the vas deferens, is placed one on each side within the cavity of the scrotum (Fig. 81). It is an oval body about an inch and a half in length, with its long axis directed upward and outward. Its two surfaces are covered by a reflection of a serous membrane called the *tunica vaginalis*. This is a remnant of the original sac of peritoneum which accompanies the testis in its descent, and is in reality a continuation of peritoneum. Its cavity contains, under normal conditions, a small amount of serum. Under pathologic conditions this serum may accumulate, giving rise to a **hydrocele** which always lies on the anterior and inner side of the testis. The testis and epididymis, as well as the greater portion of the spermatic cord, are supplied by the spermatic arteries and veins.

Both spermatic arteries arise from the aorta (see Fig. 81) below the renals. The right spermatic vein empties into the vena cava, the left spermatic vein into the left renal. The fact that the origin of these veins is so far from the place of emptying their blood, and that they are not provided with valves, renders stagnation of blood in them

in the erect position of the body easily possible. This is especially true of the left side, where the spermatic vein enters the renal at right angles, forming an additional mechanical obstruction. Hence, varicosities of the spermatic or pampiniform plexus of veins in the male are more frequent on the left than on the right side of the body. This condition is clinically known as **varicocele.**

**Descent of the Testis.**—The testes during early embryonic life lie on the posterior wall of the abdomen in the neighborhood of the kidney. Toward the end of the seventh month they lie near the abdominal ring, having pulled the spermatic artery and vein with them. Meanwhile a blind pouch, or diverticulum of the peritoneal sac, called the vaginal process, has grown downward and inward through the anterior abdominal wall toward the scrotum. It is accompanied by the testis with its vessels; the testis being accompanied by a cord-like structure, the ***gubernaculum testis.*** This gubernaculum, at its greatest development, about the sixth month, is attached above to the lower end of the testis, while below it is fixed near the inguinal region. As the testis accompanies the vaginal process, the gubernaculum atrophies, and its failure to atrophy may have much to do with the abnormal positions of the testis which occur. The testis may be found abnormally (cryptorchismus) within the abdominal cavity, within the inguinal canal, and occasionally in the groin, or even in the perineum (Fig. 97). If in the abdomen, it seldom develops, remaining atrophied throughout life. If within the inguinal canal, it is greatly exposed to injury and frequently gives rise to malignant growths (sarcoma). These abnormal positions of the testis are spoken of as cryptorchismus.

## The Rectum.

The rectum in the male is separated from the bladder by the rectovesical connective tissue and the reflection of peritoneum covering the same. It is only covered to a partial extent on its anterior and lateral walls by peritoneum. As a rule, only the upper two-thirds is covered, the lower third having no peritoneal investment. This reflection—that is, the bottom of the rectovesical pouch—is about one inch above the prostate, or three inches above the anus. It is relatively much higher in fatty subjects, while it is usually lower in emaciated ones. The rectum begins about the middle of the sacrum (the third sacral vertebra) and ends in the anal canal or anus,—the third portion of the rectum of old descriptions,—at the level of the lower edge of the levator ani muscles (see Fig. 50). The rectum proper (second portion of the rectum of old descriptions) has three more or less distinct **lateral**

bends. These are marked on the exterior by a crease and on the interior as three crescentic shelves of mucous membrane known as the rectal valves of Houston or Kohlrausch. These are of considerable importance in supporting the fecal contents when the rectum is distended. One of them is shown in figure 89. When the rectum is empty, its course is comparatively straight, and to each side of it is a large fossa of peritoneum containing a mass of small intestine, or the pelvic colon. When the rectum is full, this pararectal fossa is obliterated. Just before passing into the anal canal, the rectum is greatly dilated to form the *ampulla of the rectum* (see Fig. 50). The front of the rectum, measured from the anus, or external opening of the anal canal, has no peritoneal covering for a distance of three inches. The posterior aspect is not covered by peritoneum for five or six inches. In front and above, the peritoneum is closely adherent; at the sides and below, it is much looser. The rectum rests upon the front of the sacrum and coccyx, and below these upon the posterior part of the pelvic floor formed by the meeting of the two levator ani muscles (Fig. 103). In front, it is in relation with the bladder (Fig. 94). The **anal canal,** or third portion of the rectum of the old descriptions, begins where the rectum proper terminates, at the level of the meeting of the levator ani muscles in the median line. It is usually about 1 to 1½ inches long, and is directed downward and backward. It is surrounded by the external and internal sphincters below, and above by the lower edge of the levator ani. On each side of it is situated the ischiorectal fossa with its mass of fat (Fig. 103). Behind, it is separated from the coccyx by a quantity of mixed connective and muscular tissue. In front, it is in close relation with the bulbous and membranous portions of the urethra, and the distance to which a sound has entered in the urethra can be controlled by a finger introduced into the anal canal (Fig. 94). The **sphincters of the rectum and anal portion** are the levatores ani and internal and external sphincters. The first-named act like clamps which support the distended rectum immediately above the anal canal, and in this way suspend the weight of the feces when the rectum is distended. They are voluntary muscles. The external sphincter forms a muscular cylinder around the upper two-thirds of the anal canal, being attached in front to the median raphe of the perineum (central point in Fig. 97) and behind to the coccyx (Fig. 97). It is the principal sphincter of the anus, or external opening of the anal canal, and under ordinary circumstances is in a state of chronic contraction, so that the finger can only be inserted with difficulty into the anal canal. The internal sphincter is merely a thickening of the


Fig. 97.—Most frequent locations of testis in cases of non-descent. 1. Location of testis within the inguinal canal. 2. Location just outside of external abdominal ring. The third most frequent position (abdominal testis) is not shown in the illustration.

circular muscular coat at the end of the bowel, and its chief use is to empty the anal canal completely. It probably acts more as a detrusor or expeller than as a true sphincter, the principal sphincter action being maintained by the external sphincter. In the interior of the anal canal one notices the vertical folds of mucous membrane which are prominent in character (containing an artery and a vein), called the columns of Morgagni, and it is here that hemorrhoidal enlargements (internal) are most likely to appear. Between the two adjacent columns there is a small transverse crescentic valve-like fold which joins the end of the two columns. Behind each is found a little pocket, in which foreign particles often lodge. The epidermis around the anus is continued inward as far as the margins of the anal valves, the junction being indicated by a fine wavy line. On account of the relation of the ischiorectal fossa to the sides of the rectum and anal portion of the rectum, abscesses are likely to occur in it, due to perforation of the wall of the rectum by some foreign body, or the migration of organisms through the intact mucous membrane. Such abscesses point externally at the side of the anus (ischiorectal abscess).

The rectum and anal canal receive their blood-supply from the three (superior, middle, and inferior) hemorrhoidal arteries of each side and from the middle sacral artery. The veins are of the same name, the chief point of interest being that the superior and middle empty into the portal circulation, whereas the inferior empty into the internal iliac, a tributary of the vena cava. Thus an anastomosis exists between the two circulations. Any obstruction in the portal circulation causes the appearance of varices in the rectum (hemorrhoids). The inner wall of the **ischiorectal fossa** is formed by the levator ani and coccygeus muscle, covered by the anal fascia; the outer wall by the obturator internus, covered by the obturator fascia (Fig. 103). If an abscess in the ischiorectal fossa is not opened at the base, lateral to the anus, it may perforate the levator ani toward the apex of the fossa, which lies 2½ inches from the surface, and burrow into the cellular tissue of the pelvis around the rectum, opening into the ampulla; or it may burrow upward in the peritoneal fatty tissue of the pelvis and ascend in it to form an iliac abscess. The lymphatics from the skin of this entire region pass to the inguinal and crural glands, although those of the rectum itself pass to the retrorectal cellular tissue in front of the sacrum and to the glands in the neighborhood of the internal iliac vessels.

An **imperforate anus** may be due to a partial or complete absence of the anal membrane which separates the proctodeum in the embryo

from the hind-gut, or the hind-gut may be deficient in its lower part so that there is a considerable interval between it and the skin, or the hind-gut may open into the vagina, uterus, bladder, or the ureters, when usually no anus is evident; or, finally, the original cloaca condition of the embryo may persist. The illustration (see Fig. 93) shows one of these conditions. The specimen was removed at autopsy by the author, from a case of Dr. L. L. McArthur's, and shows the hind-gut terminating blindly below, in a large pouch which communicated with the bladder, so that intestinal gases escaped through the urethra. The communication between bladder and rectum was a mere slit in the posterior wall of the bladder. It should be one of the first duties of the obstetrician to examine the new-born child for imperforate anus.

## The Perineal Region in the Male.

The perineal region in the male lies between the pubic arch in front, the tuberosities of the ischium laterally, and the coccyx behind (see Fig. 98). It is divided into two regions, the anal and urogenital, by a line drawn between the two tuberosities of the ischia (No. 8 of Fig. 98). This line corresponds to the union of the deep layer of the superficial fascia and the base of the triangular ligament; hence, after rupture of the bulbous or the membranous urethra, urine can escape only as far back as the junction of these two fasciæ, but can pass forward to the anterior wall of the abdomen and to the scrotum, causing abscesses and gangrene if the urine is septic.

At the center of the above transverse line is the *central point of the perineum* at which the transversus perinei, bulbocavernosus, levator ani, and external sphincter have a common point of insertion. It lies one inch in front of the anus (No. 10 in Fig. 98). Immediately in front of this central point lies the bulbous portion of the urethra (Figs. 94 and 98) with Cowper's glands, which it overlaps.

A stricture of the urethra is most frequent in the bulbous portion (proximal end of pendulous portion) or at the bulbo-membranous junction. In performing external urethrotomy (perineal section) for stricture or rupture of the urethra, the incision is made in the median line down to the bulb. The superficial and deep perineal vessels and nerves can be best avoided by keeping in the median line. They are all branches of the internal pudic artery and nerve, which run along the pubic arch and send vessels and nerves toward the median line (transverse and superficial perineal artery of the bulb) (see Fig. 97). The artery of the bulb is often unavoidably severed, and gives rise to obstinate hemorrhage.


Fig. 98.—Surface markings of male perineum. 1, Tuberosities of ischium. 2, Coccyx. 3, Termination of Roser-Nélaton line. 4, Ischio-pubic ramus. 5, Spongy portion of urethra, ending at 6. 6, Bulbous end of pendulous urethra, the two black dots representing Cowper's glands. 7, Ischiorectal fossa (base of). 8, Line between two tuberosities of ischium corresponding to attachment of base of triangular ligament and deep fascia. The transverse perinei muscles lie parallel to it. 9, Margin of gluteus maximus muscle. The limits of the external sphincter are seen extending from (2), its point of attachment, to (10), central point of perineum. 10, Central point of perineum (see text). P, Left internal pudic artery giving off its inferior hemorrhoidal branches just in front of P, its transverse and superficial perineal branches opposite (8); the most anterior branch (above the figure 6) corresponds to the artery of the bulb.

## Female Pelvic Viscera.

In the adult female pelvis the **bladder** lies deeper than in the male, and, unless very full, does not rise above the symphysis pubis. It may prove an obstruction to the head during labor, if not regularly emptied. It is pushed down and forward by the pregnant uterus, causing a frequent desire to urinate. It is held in place, as in the male, by the visceral layer of the pelvic fascia (see Fig. 101). The uterus, under normal conditions, rests upon the posterior surface of the bladder, and between them there is a fold of peritoneum forming a shallow pouch, the vesico-uterine. The base of the bladder is not separated from the


Fig. 99.—Diagram designed to show the antero-posterior outline of the pelvic peritoneum in the mesial pelvic plane, with distended bladder (Ranney): *PP*, peritoneum; *R*, rectum; *U*, uterus; *B*, bladder; *S*, symphysis pubis. The vesico-abdominal, the vesico-uterine, and Douglas's pouch are made very apparent.

lower portion of the uterus and upper part of the vagina by peritoneum, but is in direct contact with them. Hence fistulous communications may exist between the bladder and the anterior wall of the vagina and cervical canal.

The **ureters** in the female (see Fig. 101) pass on either side, as in the male, from the brim of the pelvis along its lateral walls, between the parietal layer of the pelvic fascia and the peritoneum. The ureter runs forward and inward upon the upper surface of the levator ani and beneath the base of the broad ligament on either side to the

base of the bladder. It crosses below and behind the uterine artery (see Fig. 101), passes at the side and in front of the cervix uteri and the lateral fornix of the vagina, entering the base of the bladder a quarter of an inch below the anterior fornix. Its close relation to the cervix renders it a source of danger in operations on the lower part of the uterus, especially in vaginal hysterectomy. If the uterus is pulled upward and forward in abdominal operations, or downward and backward in vaginal operations, the distance between the cervix and the ureters is considerably increased. The close proximity of the ureter to the cervix, and the fact that it passes through the parametrium, render it liable to obstruction in carcinoma of the uterus, with infiltration of the broad ligaments, causing an obstruction to the flow of urine (hydro-ureter). A fistulous communication may exist between the ureter and the cervix, or between it and the vagina.

Between the bladder in front and the rectum behind lie the female reproductive organs. The **uterus** lies in the median line of the pelvis, turned slightly to the right. Its normal length is 3 inches from cervix to fundus, but only 2½ inches from the cervix to the end of the uterine cavity. The latter is the measurement usually obtained with a sound.

The uterus is covered upon its fundus and its anterior and posterior surfaces by peritoneum. Upon the anterior surface the peritoneum is reflected at the junction of the cervix and neck upon the bladder, forming the utero-vesical fold. Upon its posterior surface it is reflected so low that it invests a small portion of the posterior fornix of the vagina, and is then reflected upon the rectum, forming the recto-uterine fold. The fact that this posterior pouch, called cul-de-sac of Douglas, is so much deeper renders access to the adnexa (as the tubes and ovaries are called) easier through the space behind the cervix.

The uterus is held in its normal position of anteflexion by a number of ligaments, but in spite of these it is a very movable structure, changing its position with the distention of the rectum or bladder. One of the chief supports of the uterus, in addition to these, is the muscles of the perineum, especially the levator ani on each side.

When the perineum is not properly repaired after laceration of the same, it permits the uterus to descend in the pelvis (prolapsus uteri).

The cervix is held backward by the uterosacral ligaments and the body of the uterus is held, under normal conditions, in a position of slight anteflexion through the attachment of the round ligaments (see Figs. 99 and 100) at the junction of the lateral border and fundus. In addition to these supports, the uterus is held in place through the broad ligaments, which are simply wide peritoneal folds passing from the

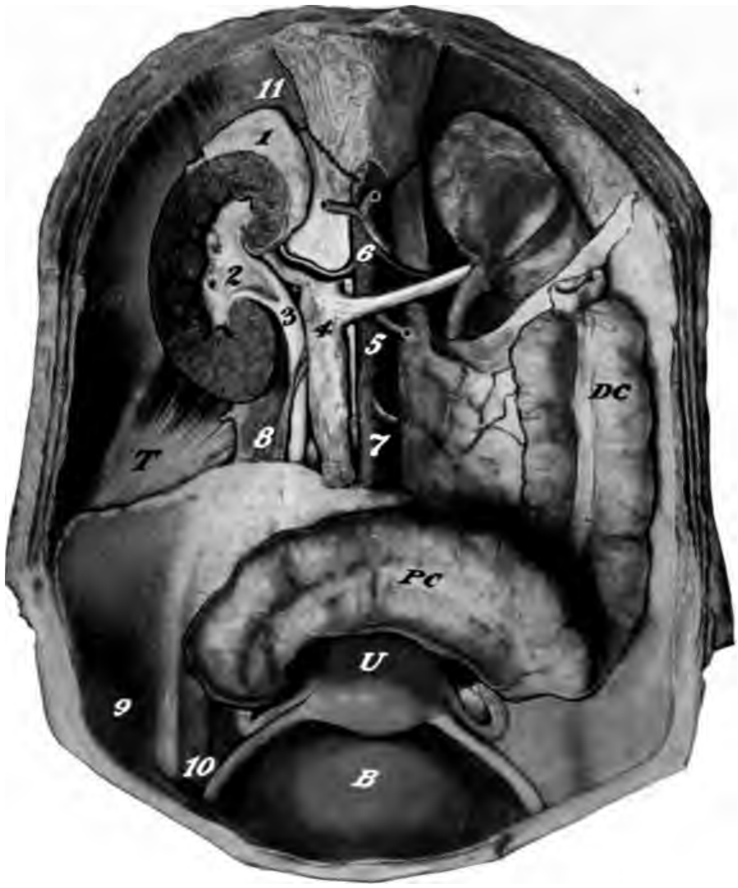


Fig. 100.—View of kidneys and other retroperitoneal structures and pelvic viscera *in situ* (female). B, Superior surface of bladder. U, Body of uterus anteflexed, resting upon bladder. On each side is seen the Fallopian tube and ovary. PC, Pelvic and iliac portions of the colon (sigmoid flexure), lifted up. DC, Descending colon. T, Transversalis muscle and fascia, upon which outer portion of kidney rests. Upon the right side the peritoneum lining the posterior wall of the abdomen has been removed; upon the left side it covers the lower pole of the kidney. The right kidney is seen in vertical section. 1, Right suprarenal capsule. 2, Pelvis of right kidney. 3, Beginning of ureter (superior isthmus). 4, Inferior vena cava, disappearing above through the diaphragm. 5, Abdominal aorta. The figure is placed just below the point at which the superior mesenteric is given off. Above the superior mesenteric artery the left renal vein is seen. 6, Abdominal aorta at point renal arteries are given off. Above the figure the three branches of the celiac axis can be seen. 7, Placed below point on aorta at which inferior mesenteric artery is given off. 8, Quadratus lumborum muscle, upon which inner edge of kidney rests. 9, Peritoneum lining iliac fossa. 10, Round ligaments.

lateral border of the uterus to the pelvic wall. During pregnancy all of these ligaments undergo great hyperplasia, and are apt to become relaxed afterward, allowing the uterus, owing to its greater weight after pregnancy, to be displaced in the pelvis.

To sum up, the uterus may be said to be supported from above and below, the lower support being formed by the perineal body and the visceral layer of the pelvic fascia. The upper supports are the round, broad, and uterosacral ligaments. The uterus is so movable and lies so deep in the pelvis that in the non-pregnant condition it is not likely to be injured by external violence, such as a fall or a blow upon the abdomen.

Between the folds of the broad ligament is a loose areolar tissue in which lie the uterine artery and the vessels supplying the ovary and tube (ovarian arteries). They are accompanied in this ***parametrial tissue***, as it is called, by the uterine and ovarian veins, as well as the lymphatics and nerves which supply the uterus. This parametrial cellular tissue is continuous with the subperitoneal cellular tissue lying between the visceral layer of the pelvic fascia and the peritoneum, being continuous again above the pelvic brim with the cellular tissue of the iliac fossa, and, in fact, with the subperitoneal cellular tissue all over the abdominal cavity. Abscesses arising from the uterus, especially those incident to puerperal infection, may migrate through the lymphatics of the uterine wall into this parametrial tissue and cause abscesses which are especially frequently situated behind and lateral to the uterus, pushing it forward and to the side. Such pelvic abscesses are best opened through the posterior fornix of the vagina. If the suppuration spreads in the parametrial tissue (wrongly called pelvic cellulitis), it may extend to the iliac fossa, causing a bulging above Poupart's ligament, where it is necessary at times to open it; or it may follow along the retroperitoneal tissue as high up as the kidney, dissecting up the peritoneum as it advances. Such abscesses, if under great tension, may rupture into the general peritoneal cavity.

Thrombosis of the uterine veins lying between the layers of the broad ligament is one of the most constant pathologic conditions found in puerperal sepsis.

The **Fallopian tubes** lie between the two layers of the broad ligaments along their upper margin, opening into the uterus at its lateral angles, or cornua, this latter portion, called the uterine portion, is imbedded in the substance of the uterine wall. The lumen of the canal gradually increases in width as it passes outward, being widest close to the abdominal opening (ampulla), the narrower portion between the

ampulla and uterine portion of the tube being called the *isthmus.* Each tube passes horizontally upward and outward until it reaches the upper edge of the ovary, where it arches backward, descending along the posterior border of the ovary and resting against the inner surface of the gland (see Figs. 100 and 101).

**Extrauterine pregnancy** is most apt to occur in the ampulla, the product of conception either being discharged through the abdominal ostium (tubal abortion), or the walls of the tube rupturing, giving rise to very severe hemorrhage. When the abdominal opening of the tube is closed through inflammation, pus or serum may collect within the tube, giving it a peculiar shape like that of a post-horn (pyosalpinx or hydrosalpinx). The tube is about 4½ inches in length.

The **ovary,** when it occupies its usual position, lies with its long axis vertical, its outer surface lying against the lateral wall of the pelvis, its inner surface looking toward the pelvic cavity.

The lower pole of the ovary is connected with the lateral angle of the uterus by the ovarian ligament. The ovary lies upon the posterior aspect of the broad ligament.

The **blood-supply of the uterus** is received from the uterine and the ovarian arteries. The vessels derived from these two sources communicate freely with each other. The uterine artery lies close to the lateral wall of the uterus and its pulsations may be felt through the lateral fornix of the vagina. The ovarian arteries correspond to the spermatic arteries of the male, and have a similar origin (see Figs. 100 and 101). They run between the layers of the broad ligament parallel to the Fallopian tubes, until they reach the lateral wall of the uterus. That portion of the broad ligament which they enter is called the infundibulo-pelvic ligament. The veins of the uterus pass into the internal iliac veins. The ovarian arteries also supply the ovaries, the tubes being chiefly nourished by a branch of the uterine artery, so that it is necessary, in extirpating the tube and ovary, to consider their double source of supply from the ovarian artery through the infundibulo-pelvic ligament, which it is necessary to ligate, and from the uterine artery at the inner end of the tube (Fig. 101).

The **lymphatics** of the ovary generally arise from those of the upper part of the uterus, and end in the lumbar lymphatic glands. Those of the tube also end in the lumbar glands. The lymphatics of the uterus end for the most part in the lumbar lymphatics. Along the course of the round ligament there are a few lymphatic vessels which establish a relation between the lymphatic network surrounding the uterus and the inguinal glands. The lymphatic glands from the cervix

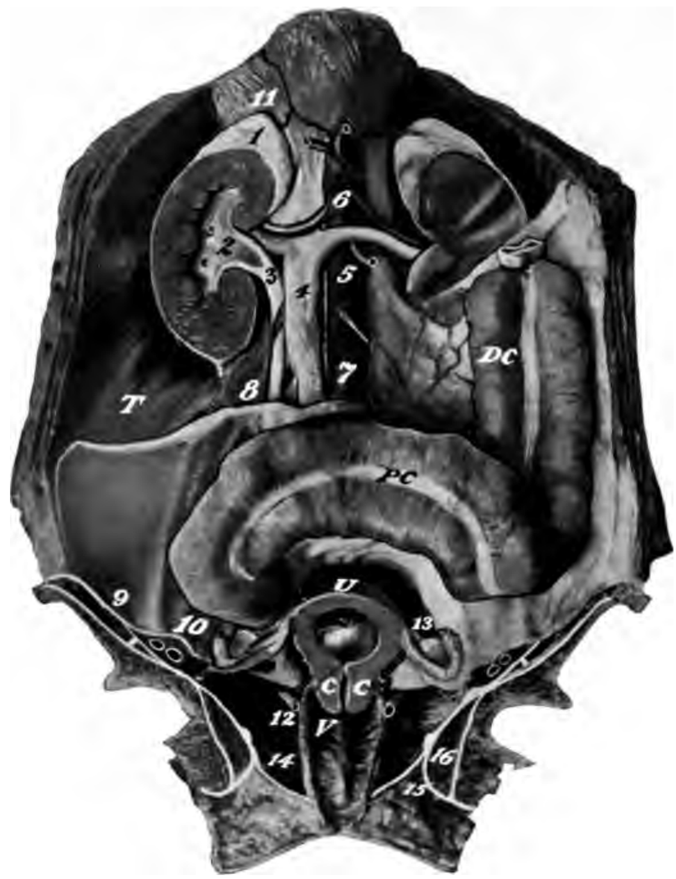


Fig. 101.—Same as Fig. 100, but shows pelvis in coronal section. 1, Suprarenal capsule. 2, Pelvis of kidney. 3, Beginning of ureter. 4, Inferior vena cava. Just above the figure 4 the renal veins empty. 5, Abdominal aorta just below point at which superior mesenteric is given off. 6, Abdominal aorta opposite origin of renal arteries. Above it the three branches of the celiac axis can be seen. 7, Abdominal aorta, just below point of origin of inferior mesenteric. 8, Quadratus lumborum upon which kidney lies. 9, Peritoneum lining iliac fossa. Beneath the figure the iliopsoas muscle can be seen, the white dot representing the anterior crural nerve. 10, Peritoneum of iliac fossa continued so as to form pelvic peritoneum. Below the figure 10 the external iliac artery and vein are seen. 11, Internal and external arcuate ligaments of diaphragm. 12, Ureter, lying one inch to right and left sides, respectively, of cervix uteri. 13, Uterovesical pouch (cul-de-sac of Douglas), at its lateral edge. Below the figure the left ovary and tube are seen ***in situ***. The uterus and adnexa are at a higher level than normal (level of inlet), on account of the pregnant uterus. 14, Levator ani. The parametric space is exaggerated in size, on account of the high position of the uterus. 15, Ischiorectal space 16, Obturator internus, lying between the parietal layer of pelvic fascia and the lateral walls of the pelvis. The white spot to the inner side of 16 corresponds to the level of the white line, from which the levator ani arises, and at this point the visceral layer of the pelvic fascia passes inward, above the ischiorectal fossa. U, Fundus of uterus. The uterine cavity is seen distended by a fetus and membranes. CC, Cervical portion of uterus (cervix uteri); between the two letters the cervical canal lies, with narrow internal os and wider external os. V, Walls of vagina. PC, Pelvic and iliac portions of colon turned upward (sigmoid flexure). DC, Descending colon, lying upon posterior wall of abdomen and crossing lower pole of left kidney. T, Transversalis muscle. Above the ureter (12) the uterine artery is seen on each side.


Fig. 102.—View of external genitalia of female, and cross-section of upper third of thigh. 1, Labia majora. 2, Labia minora. 3, Perineum. 4, Anus. 5, Internal saphenous vein. 6, Femoral vein. 7, Femoral artery. 8, Anterior crural nerve. Upon the left side of the body the black area below 7 indicates the profunda femoris. 9, Adductor longus muscle. 10, Adductor magnus. 11, Sartorius. 12 and 13, Vastus externus and internus. 14, Biceps. 15, Semimembranosus. 16, Semitendinosus. S, Sciatic nerve. P, Pectineus muscle. R, Rectus femoris. F, Shaft of femur.

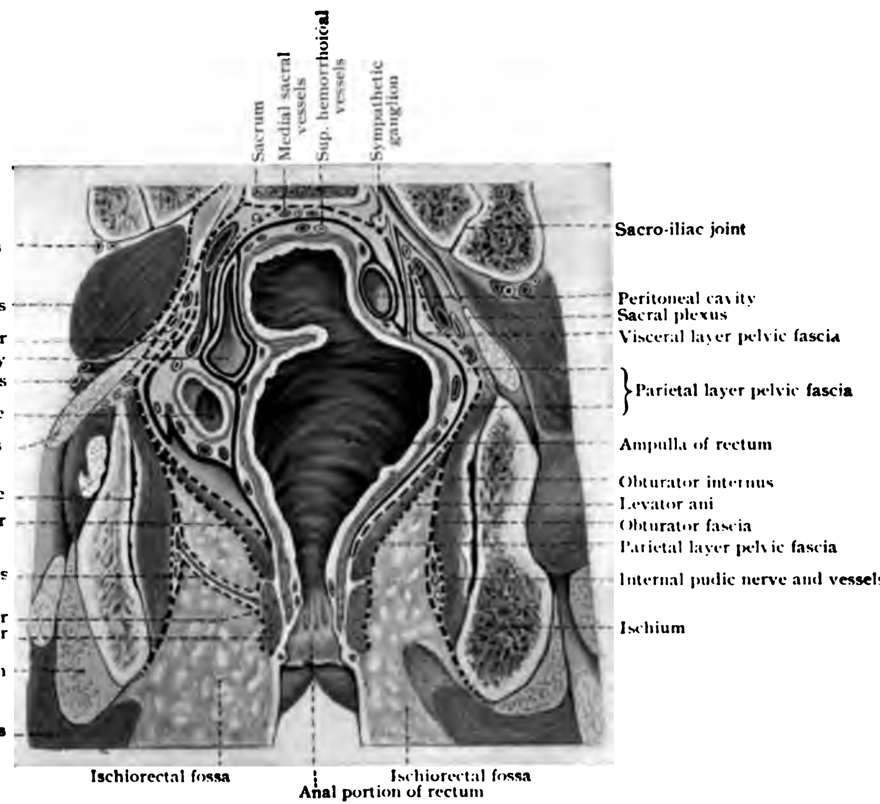


**Fig. 103.—Vertical section (after Joessel) of male pelvis to show arrangement of pelvic fascia. The visceral layer is shown as a continuous, the parietal layer as a dotted line.**

uteri end toward the bifurcation of the common iliac artery. **Carcinoma** of the cervix is far more frequent than that of the body of the uterus, and its transmission occurs through the lymphatics lying in the parametria on either side of the uterus toward the lumbar glands.

The uterine canal opens into the vagina, the angle between the axes of the two being a little greater than a right angle. That portion of the cervix which projects into the vagina is called the vaginal portion. Its outer aspect is covered with pavement epithelium which is continuous with that of the vagina; but where the cervical canal begins, it becomes cylindrical in character, and this point of transition is a frequent starting-point of carcinoma, as are also the many mucous glands lining the cervical canal close to the external os. Carcinoma of the cervix is far more frequent than is carcinoma of the body of the uterus.

In making a **vaginal examination,** one feels the vaginal portion of the cervix, the os being felt as a small transverse slit in nulliparæ. Above and behind the cervix is the posterior fornix of the vagina, which is in close proximity to the recto-uterine pouch, or pouch of Douglas. In front of the cervix is the more shallow anterior fornix, while lying in front of the anterior vaginal wall the urethra can be detected as a cylindrical cord-like thickening. Lateral to the cervix can be felt the lower part of the broad ligament and the pulsations of the uterine artery, on each side.

The rectum in the female is in contact above with the pouch of Douglas and below with the vagina; lateral to it, the ischiorectal fossæ exist, as in the male (Fig. 101).

Abscesses in the pouch of Douglas not infrequently rupture into the rectum.

The **external genitalia in the female** (see Fig. 102) include the labia majora and the labia minora, between which is the opening of the vagina. At their point of junction is the clitoris, and between it and the opening, or *introitus vaginæ*, is the external orifice of the urethra, the urethral canal in the female being short—only 1½ inches long.

The pelvic viscera in the female are supported by the pelvic fascia, which is the same as in the male. (See description of the Pelvis in General.) The pelvic diaphragm is composed of the levatores ani and coccygeus muscles, which form, in addition to the pelvic fascia, a strong support for the uterus, bladder, and rectum. This pelvic diaphragm pulls the vagina upward during childbirth, pushing the child's head forward so as to cause it to rotate under the pubic arch. The pelvic floor is also made up of the perineal fascia and muscles, and the perineal body, which is the name given to the tissue between the rectum and vagina.

Of all of these structures, the levatores ani and the perineal body contribute the chief support from below.

The perineal body is composed of the posterior ends of the bulbo-cavernosus muscles, fibers belonging to the superficial transversus perinei, the internal and external sphincter ani, and the levator ani muscles. It corresponds in a way to the central point of the perineum in the male, where the muscles, fasciæ, and ligaments meet. These structures all being attached to the surrounding bones, the perineal body becomes the chief support of the whole pelvic floor. When it is torn, the vagina, rectum, and uterus lose one of their chief supports and are apt to prolapse. During childbirth the perineal body forms a strong barrier, against which the child is pressed. It resists so firmly that it is frequently so stretched as to be little more than the thickness of paper.

## Nerves of the Abdominal Cavity.

The nerves which supply the abdominal viscera, the diaphragm, and the muscles of the abdominal wall are all in close relation to each other. They belong to the cerebrospinal and sympathetic systems, but communicate with each other by many branches; so that lesions of the viscera are often referred, as was explained on page 232, to the corresponding point (on the skin) of distribution of the spinal segment which communicates with it. The fact that the skin and muscles of the abdomen are supplied by branches of the last dorsal and lumbar nerves, and that these nerves have many anastomoses with the sympathetic, is also of great importance. Inflammation of the viscera causes reflex contraction of the abdominal muscles and extreme sensitiveness of the corresponding area of skin, thus acting as a splint for the inflamed viscus. Irritations of the skin—for example, a blow upon the abdomen, or burns—are followed by a reflex contraction of the abdominal muscles, unless, as often happens, the blow is so sudden as not to permit of this protection on the part of the muscles. The two **vagi nerves** after penetrating the diaphragm, supply the lower end of the esophagus and the entire stomach. The right vagus (see Fig. 104) enters the abdominal cavity with the esophagus, and is distributed to the posterior surface of the stomach. It forms the posterior gastric plexus, and sends communicating branches to the celiac, splenic, and renal plexuses. The left vagus is distributed upon the anterior surface of the stomach, forming the anterior gastric plexus, and sends communicating branches to the hepatic plexuses of the sympathetic. The two **phrenic nerves** are distributed chiefly to the inferior surface of the diaphragm (subperitoneal branches).

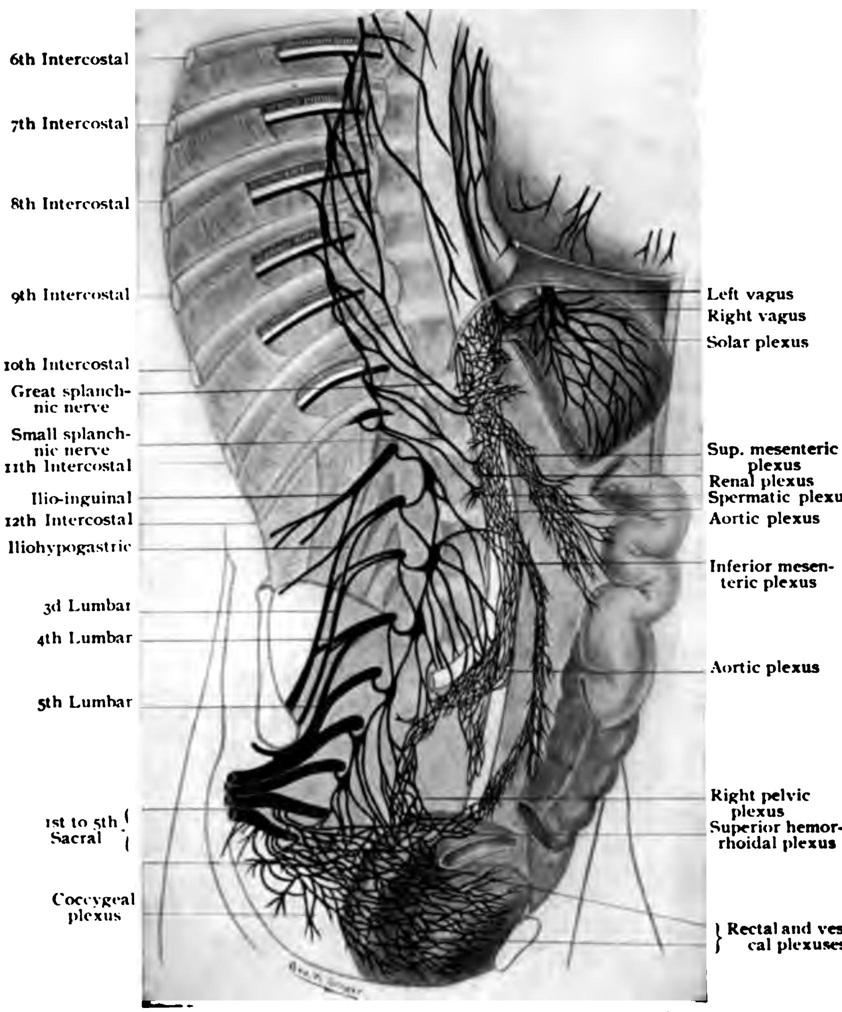


Fig. 104.—Nerve-supply of abdominal viscera and relations of spinal nerves to sympathetic (after Quain).

Both nerves communicate with the solar plexus of the sympathetic. This latter communication explains the fixation of the diaphragm in inflammatory conditions of the peritoneum or of the viscera of the abdominal cavity, as well as the dyspnea due to both mechanical and nerve interference with the action of the diaphragm in septic peritonitis. It will also explain why a diaphragmatic pleurisy or a subdiaphragmatic peritonitis will often give rise to the symptoms of severe intestinal lesions.

The **abdominal sympathetic** can be divided into a middle and two lateral portions. The middle consists of a number of plexuses (see Fig. 104) which communicate with the lateral cords (see below). The most important of these plexuses are the solar, the superior mesenteric, the renal, the aortic, the inferior mesenteric, the spermatic, the right pelvic, the hemorrhoidal, the rectal, and the vesical plexuses. These plexuses are made up to a great extent of branches received from the lateral cords of the sympathetics (especially the upper plexuses); the great and small splanchnic nerves penetrating the diaphragm (see Fig. 104) at its center, and connecting with each other to form the celiac plexus. All of the portions of the abdominal sympathetics, especially the upper, are in direct communication with the spinal cord (see Fig. 104) through the rami communicantes.

# UPPER EXTREMITY.

**Examination of the Shoulder and Upper Extremity in the Living.**—1. Note that the shoulder has a convex outline dependent on the development of the deltoid muscle and the underlying head of the humerus. If the muscle is atrophied, or the head absent, as in dislocation, there is a concavity present below the acromion process (see Fig. 105).

2. The deltoid hangs like a curtain from the outer end of the clavicle and acromion, covering the humerus. Palpate it to its insertion at the deltoid tubercle on the outer side of the humerus.

3. The clavicle can be felt in its entire length. Note the junction of its two curves (middle third), where the bone most frequently breaks. The prominent sternoclavicular joint at the inner end of the clavicle, and the acromioclavicular at its outer end, can be readily palpated.

4. The exact relation of the outer end of the clavicle to the acromion must be noted. The groove between them runs in an antero-posterior direction. Motion at this joint is at times mistaken for a fracture, especially in children.

5. The greater part of the spine of the scapula and acromion can be felt subcutaneously. The outer border of the acromion is used in measuring the arm (see Fig. 107).

6. Just beneath the deltoid the tuberosities of the humerus are to be palpated.

7. Place the fingers high up in the axilla and the head of the humerus can be felt in the glenoid cavity, extending beyond the edges of the same.

8. Observe the movements of the head of the humerus by placing the thumb in front and the fingers behind the deltoid muscle, and rotate the arm with elbow flexed. The head faces in the direction of the internal condyle (see Fig. 106).

9. Just below the outer end of the clavicle is a groove indicating the point where the thorax is separated from the shoulder. In this groove (infraclavicular fossa, or Mohrenheim's groove), about two fingerbreadths below the clavicle, the coracoid process can be felt. Below the groove is the pectoralis major, above it the deltoid. In subcoracoid dislocation of the humerus (Fig. 105) the head of the bone can be felt in this groove. In the groove lie the cephalic vein and a branch of the acromiothoracic artery superficially, and the axillary vessels and brachial plexus at a deeper level (see Fig. 108).

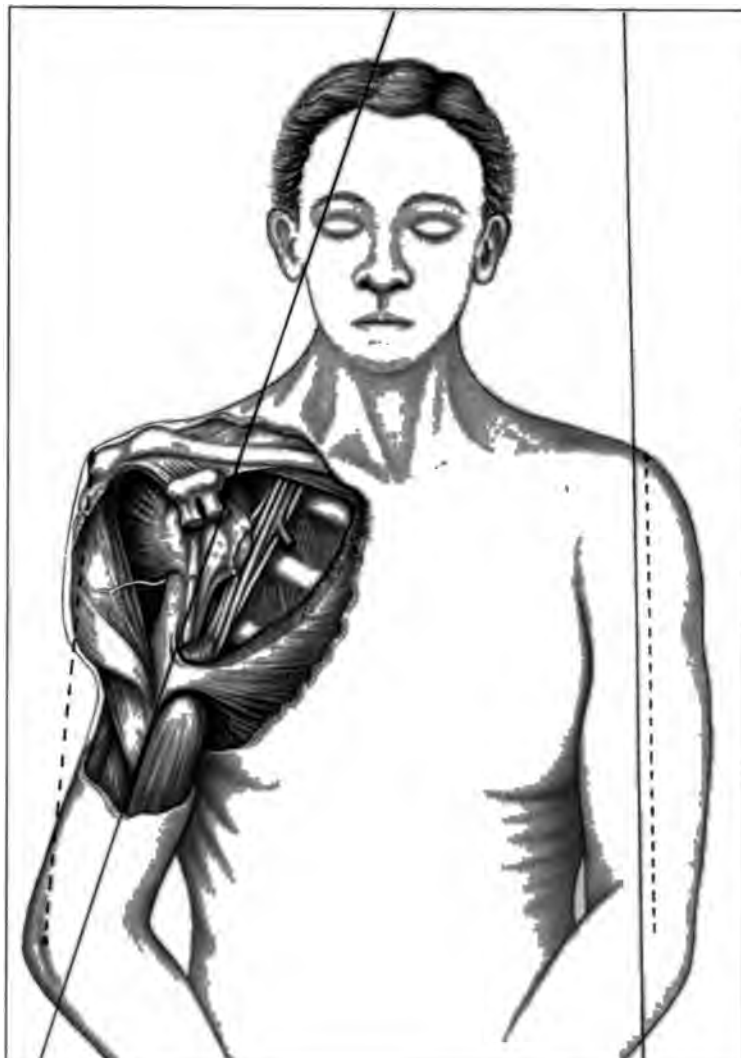

Fig. 105. Subcoracoid dislocation of the humerus (modified from Helferich and Hoffa), showing how the head may press upon the brachial plexus and axillary vessels, and also showing the change in the axis of the arm as a result of this dislocation, and the apparent lengthening of the arm, as measured from the acromion process to the external condyle.

Fig. 106.—Method of examination to be employed in making a differential diagnosis between dislocation of the shoulder-joint and fracture of the anatomical or surgical neck of the humerus. This illustration shows the manner of examining the head of the humerus in order to determine whether it has its normal range of rotation, thus aiding in ascertaining whether the head of the humerus lies in the glenoid cavity. The method consists in grasping the forearm of the patient close to the wrist with one hand, while the head of the humerus is held between the thumb in front and the remaining fingers behind, being along the anterior and posterior borders respectively of the deltoid muscle.


**Fig. 107.**—Line of measurement of arm. The measurement is made along the line 1, from the acromion process (Ac.Pr.) to external condyle (Ex. Cond.). Clavicle (Cl.), showing the joint between the acromion process and clavicle.

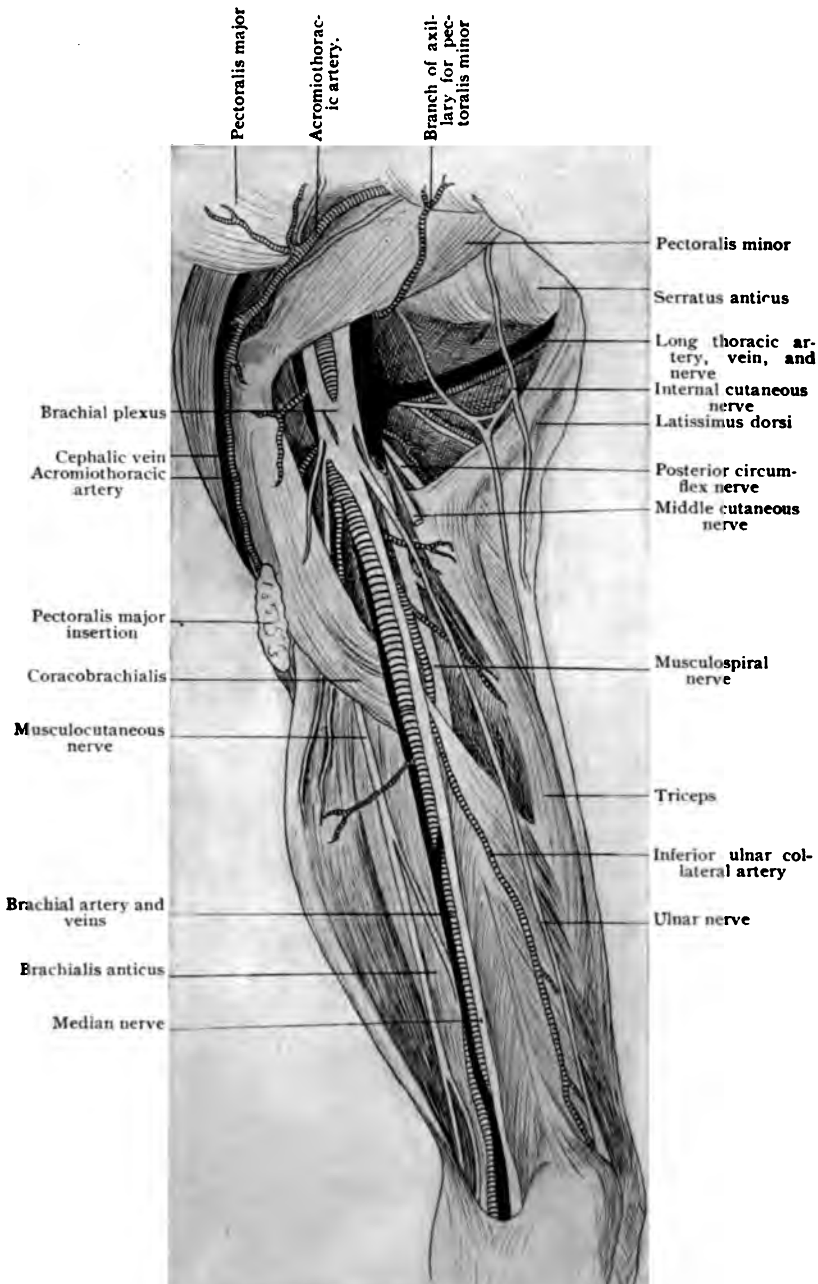


Fig. 108.—Dissection of brachial region (Henle).


Fig. 100.—Movements of joints of upper extremity. Maximum flexion of elbow (1) and of wrist-joint (2), and maximum extension of elbow (3) and wrist-joint (4). 5 and 6, Best points to measure circumferences of forearm and arm.

Fig. 110.—Surface markings of principal blood-vessels and nerves of arm and of tendon-sheaths of hand. 1, Axillary artery. 2, Musculospiral nerve, shown in heavy dotted outline, indicating its course on the back of the arm, its continuation as the radial nerve being shown in the lighter dotted outline. 3, Brachial artery. 4, Radial artery. 5, Ulnar artery. 6, Median nerve. 7, Ulnar nerve. In the hand the flexor tendon-sheaths are seen in the following relations: That of the thumb communicates with the common flexor-sheath under the annular ligament; that of the little finger extends to this common sac and often communicates with it; the distal set of the index, middle, and ring fingers extends from the middle of the hand to the middle of the last phalanx, the proximal is shown at the wrist.

10. Palpate the anterior and posterior wall of the axilla, formed by the pectoralis major and latissimus dorsi respectively.

11. Observe the movements of the shoulder-joint. They are: (*a*) Abduction (raising arm away from side of body) (see Fig. 109). Abduction is carried out principally through the action of the deltoid and supraspinatus muscles. (*b*) Abduction (bringing arm toward median line of body), executed by action of teres major and minor, pectoralis major, and latissimus dorsi. (*c*) Flexion (raising the arm in anterior and posterior direction forward). (*d*) Extension, raising arm backward, upward and inward. (*e*) Rotation and circumduction.

12. Passing downward from the acromion to the arm is the bicipital groove, and running down to the upper end of the radius, where it is inserted by a firm tendon, the biceps muscle can be felt. On either side of the biceps there is a depression or groove (internal and external bicipital groove). On the inner side is the coracobrachialis muscle.

13. Between this latter muscle and the biceps the brachial artery and some of the branches (median and ulnar) of the brachial plexus can be felt in the inner groove, and the basilic vein seen in the skin passing upward (see Figs. 108 and 110).

14. On the outer side of the biceps the cephalic vein is seen. The round outline of the humerus can be felt on both sides of the biceps.

15. In thin individuals one can feel the musculospiral nerve (Fig. 111). in its groove on the outer side of the biceps, at the middle third of the bone (just below the insertion of the deltoid).

16. Along the posterior aspect of the arm the triceps muscle is felt, attached by its tendon below into the olecranon process.

17. Note the movements of the elbow-joint; they are flexion and extension, the former being carried out principally by the biceps, the latter by the triceps.

18. At the front of the elbow, by compressing the arm above so as to obstruct the return flow, the veins lying subcutaneously in front of the joint can be readily distinguished. The median vein is seen to divide into an outer or median cephalic, and an inner or median basilic vein (see Figs. 56 and 114). The former joins over the external condyle with the radial to form the cephalic, the latter (median basilic) joins with the ulnar to form the basilic.

19. On either side of the biceps tendon there is a muscular elevation. On the outer it corresponds to the supinator longus and common extensor mass; on the inner, to the pronator radii teres and common set of flexors. Between the latter and the biceps tendon there is a groove in which the termination of the brachial artery is palpable and the

median nerve can be felt as a firm cord. On deep pressure the rotary movements of the head of the radius can be felt, just external to the supinator longus, when the forearm is pronated and supinated alternately.

20. At the back of the elbow the two condyles of the humerus and the olecranon process of the ulna can be readily felt. When the arm is extended, the tip of the olecranon is in a straight line with the two condyles (see Fig. 113). When the arm is flexed at a right angle, these three points will not be found in the same line, the olecranon tip is then about ½ inch (1 cm.) lower than the two condyles. This relation, as will be seen later, is of great value in the diagnosis of injuries in the vicinity of the elbow. Between the internal condyle and the olecranon there is a depression in which the ulnar nerve lies.

21. The supinated forearm frequently forms with the upper arm an angle known as the carrying angle (see Fig. 58). It varies normally within very wide limits.

22. On the anterior surface of the forearm the two muscular prominences, above described as lying on either side of the biceps tendon, gradually converge in the upper third of the forearm into one muscular mass, from which various tendons can be seen to arise.

23. When the hand is flexed upon the forearm several prominent tendons can be distinguished just above the wrist. Most externally is that of the flexor carpi radialis; most internally, that of the flexor carpi ulnaris; and between these, those of the flexor sublimis digitorum. Occasionally the median nerve can be felt on the inner side of the flexor carpi radialis tendon. Upon its outer side the radial artery can be felt. The ulnar artery lies on the outer side of the flexor carpi ulnaris tendon (see Fig. 115.)

24. The radius can be felt upon the anterior aspect of the forearm, in its lower two-thirds; the ulna can be felt only indistinctly, except in its lower third on the anterior, but along its entire length upon the posterior aspect.

25. Just distal to the lower end of the radius (in front) the prominent scaphoid bone can be felt. The depression upon its inner or ulnar side corresponds to the wrist-joint. The hypothenar eminence passes distally from the inner side of this depression, the thenar from its outer. These are the muscular ridges which form the boundaries of the palm of the hand. When the fingers are flexed, prominences can be felt in the palm, due to the flexor tendons. When the hand is supine, creases which form an irregular letter M can be seen in the palm, with base toward the ulnar side; the distal portion marks the proximal termination of

Fig. 111.—Relations of circumflex and musculospiral nerves to surgical neck and shaft of humerus. 1, Coracoid process. 2, Posterior circumflex nerve, shown in dotted line as it winds around the posterior aspect of the surgical neck of the humerus (H). 3, Musculospiral nerve, shown in dotted outline as it curves around the posterior aspect of the middle third of the humerus in the musculospiral groove.

Fig. 112.—Method of palpation of head of radius. In examining the head of the radius of the left arm as shown in the illustration, the surgeon grasps the patient's hand with his own left hand as though he were shaking hands. The surgeon grasps the head of the radius (which is to be found just beneath the external condyle of the humerus) between the thumb and index finger of the right hand. The patient's hand is alternately supinated and pronated while the surgeon's right hand can feel the rotation of the head of the radius. On the right side the hands of the examiner are simply reversed.

Fig. 113.—Surface markings of the principal nerves of the arm, as seen from behind, and relation of the anatomic points at the elbow. 1, Circumflex nerve, as it winds around the surgical neck of the humerus. 2, Musculospiral nerve, as it winds around the posterior aspect of the shaft of the humerus. 3, Ulnar nerve, projected on the posterior aspect of the arm, which it reaches to pass between 6 and 7, internal condyle and olecranon process. 4, Line joining two condyles. 5, External condyle. 6, Internal condyle. 7, Olecranon process. When arm is extended these three points are in a straight line, as seen on the right side. When arm is flexed, as on the left, they form an angle, the olecranon process lying below a line (4) joining the external and internal condyles. 8, Position of olecranon bursa. 9, Relation of head of radius to outer condyle.

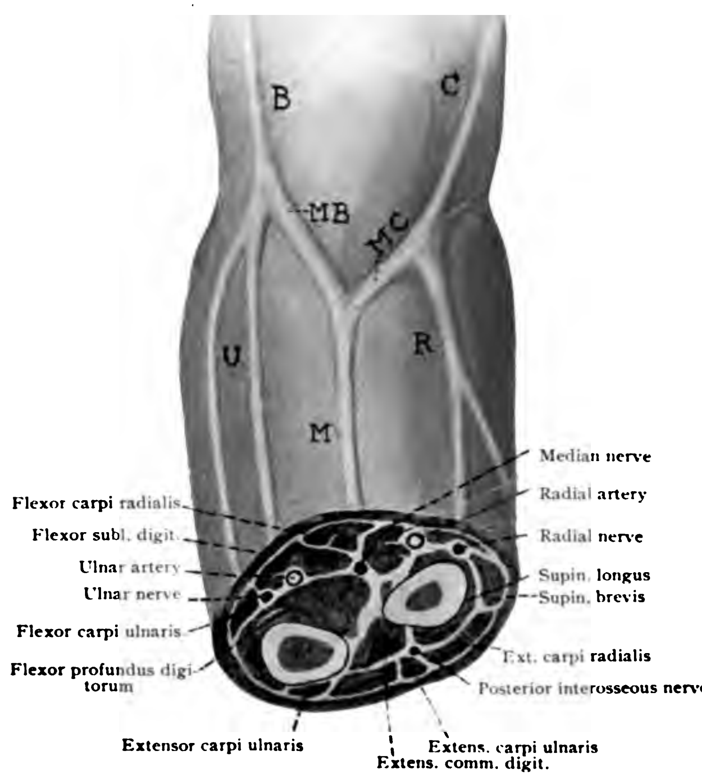


Fig. 114.—Cross-section at middle of left forearm; also showing veins at bend of elbow. U, Ulnar vein; M, Median vein; R, Radial vein; MC, Median cephalic vein; MB, Median basilic vein; B, Basilic vein; C, Cephalic vein.

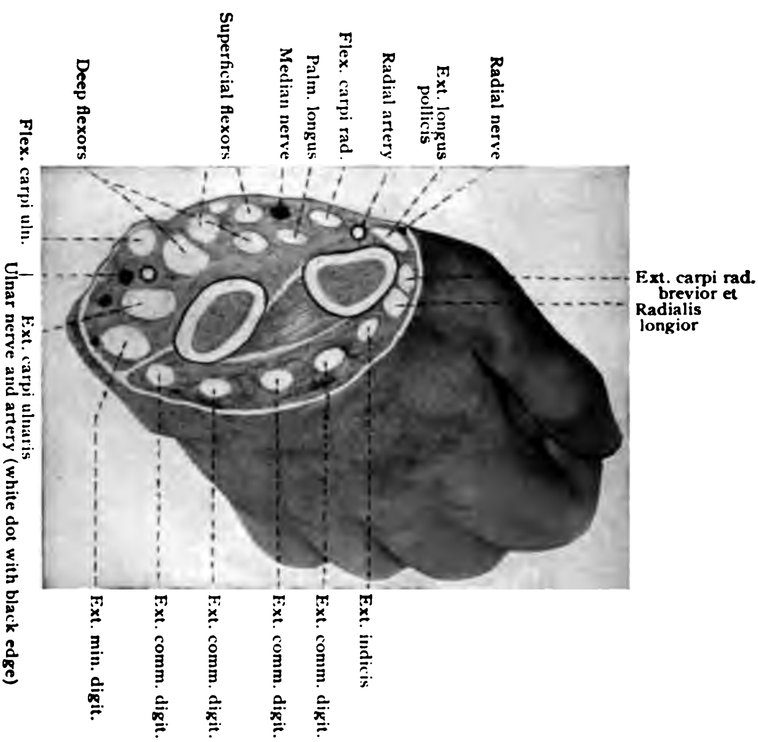


Fig. 115.—Cross-section just above wrist.

Fig. 116.—Epiphyses in boy, aged six. 1, Upper epiphysis of humerus. 2, Shaft of humerus. 3, Lower epiphysis of humerus. 4, Upper epiphysis of ulna. 5, Shaft of ulna. 6, Lower epiphysis of ulna. 8, Shaft of radius, above which is the upper epiphysis. 9, Lower epiphysis of radius. 10, Anterior superior spine of ilium. 11, Head of femur, showing epiphyseal line joining it to the neck. 12, Greater trochanteric epiphysis. 13, Shaft of femur. 14, Lower epiphysis of femur. 15, Upper epiphysis of tibia. 16, Shaft of tibia. 18, Lower epiphyses of tibia and fibula. 19, Shaft of fibula, above which is the upper epiphysis of the fibula.

the flexor tendon-sheaths for the fingers (see Fig. 110). Inside of the creases forming this letter M lies the greater portion of the superficial palmar arch and the terminations of the proximal and distal set of flexor tendon-sheaths.

26. Along the middle of the back of the forearm is seen a muscular prominence formed by the extensor communis digitorum, whose tendons become prominent over the back of the hand when the fingers are extended. The groove to its inner side corresponds to the posterior border of the ulna. When the thumb is extended, a prominence is seen running obliquely across the lower third of the radius. It is formed by the extensors of the thumb. Between two of these (seen when thumb is forcibly extended) is the tabatière, or depression known as the "Frenchman's snuff-box." In it the radial artery lies as it passes across the back of the metacarpal bone of the thumb.

27. The shafts and heads of the metacarpal bones, especially that of the thumb, can be distinctly felt on the dorsum of the hand. Along the back of each bone can be felt the corresponding extensor tendon when the fingers are extended.

28. Where the hand and forearm meet, there is a distinct depression on the dorsum, corresponding to the wrist-joint. When the fingers are fully flexed, the gap corresponding to the metacarpophalangeal joint can be felt just distal to the head of each metacarpal bone. Between the first and second metacarpal bones is seen the prominent first interosseous muscle. The extensor tendons cannot be felt along the back of the fingers. The interphalangeal joints are best examined when the fingers are alternately flexed and extended. The surface veins are very distinct on the dorsum of the hand.

29. Observe the movements of the wrist-joint (see Fig. 109). They consist of flexion and extension. Note the movements of the fingers—flexion and extension, abduction and adduction. In addition, the thumb has the power of circumduction. Note the action of the interossei and lumbricales. They cause flexion at the metacarpophalangeal articulation. The flexor sublimis and flexor profundus together flex the proximal interphalangeal joints. The flexor profundus alone acts on the last or second phalangeal joints.

30. Mark on the surface of the body (see Fig. 116) the position of the epiphyseal cartilages of the humerus, radius, and ulna.

## Surface Markings.

1. The course of the **axillary artery** when the arm is raised from the side (abducted) is represented by a line drawn **from about the middle of**

the clavicle to the inner side of the coracobrachialis (junction of anterior and middle thirds of axilla). (See Fig. 110.)

2. The **axillary vein** corresponds to the above (in the same position of the arm), but lies in front of the artery. When the arm hangs at the side, the vein lies on the inner side of the artery (see Figs. 108 and 110).

3. The **brachial artery** corresponds to a line drawn along the inner bend of the elbow; a line from the latter point to the scaphoid bone represents the radial artery; one to the pisiform bone, the course of the ulnar artery (see Fig. 110).

4. The **circumflex nerve and posterior circumflex artery** lie about a finger's-breadth above the center of the vertical axis of the deltoid muscle (see Fig. 110).

5. The **median nerve** corresponds in the upper arm, as far as the bend of the elbow, to the course of the brachial artery, *i. e.*, along inner border of biceps; from this point down to the hand it follows closely the median line of the forearm.

6. The course of the **ulnar nerve** corresponds to a line drawn from the apex of the axilla to the internal condyle, and from this point along the ulnar side of the arm to the wrist on the radial side of the flexor carpi ulnaris tendon.

7. The course of the **musculospiral nerve** corresponds to a line drawn from the axilla obliquely around the back of the upper arm to the external condyle (point of division of the nerve). This line crosses the humerus at the junction of its lower and middle thirds (Figs. 110, 113).

## The Shoulder Region.

This comprises the clavicle, scapula, upper end of the humerus, shoulder-joint, axilla, and soft parts covering them. The **skin** is of medium thickness except over the clavicle, where it is very thin and elastic. In the subcutaneous tissue lie the terminal branches of the superficial cervical plexus (Fig. 23). Beneath the clavicle lie the subclavian artery and vein upon the first rib, the vein in front. The main trunks of the brachial plexus and the vessels are separated from the clavicle by the thick subclavius muscle, which protects them from injury in fractures of the clavicle.

**Fractures of the Clavicle.**—The clavicle is more frequently broken than any other bone, on account of its exposed position. The most frequent seat is at the middle third of the bone, where the two curves meet. The inner fragment is pulled upward by the sternocleidomastoid, the outer forward by the pectoralis major and the weight of the limb (see

Fig. 117). The deformity is corrected by bringing the arm well back and supporting the elbow. Greenstick fracture is very frequent in children. Cases have been reported of injury to the brachial plexus and to the subclavian artery and vein from a fragment of bone in fractures of the clavicle; but this is rare, as stated above, owing to the protection given them by the subclavius muscle.

At the inner end of the clavicle is the sternoclavicular, at its outer the acromioclavicular joint. The sternoclavicular joint is strongly protected by ligaments, so that it is very firm and only a slight range of motion is permitted. It is not infrequently the seat of tuberculosis.

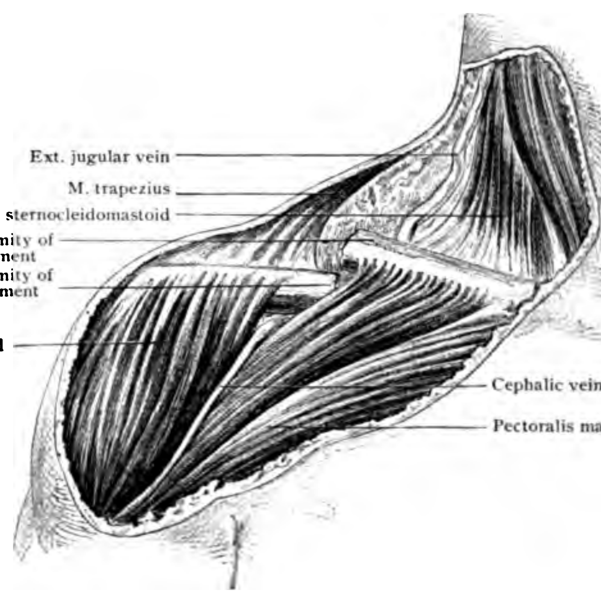


Fig. 117.—Fracture of the middle portion of the clavicle (Anger).

Dislocation upward at this joint is most frequent, and is due to indirect violence, the force acting upon the shoulder. The sternoclavicular joint is V-shaped, a point to be remembered in disarticulating it at autopsies. The acromioclavicular joint is simpler; its articular surfaces are in a sagittal plane and are surrounded by a capsule strengthened by the acromioclavicular ligament below. The two joint surfaces lie in a plane which is directed downward and inward. Dislocation upward of the outer end of the clavicle is the more frequent, and the bone is kept in place with great difficulty. It is often necessary to wire the two joint surfaces together.

The deep pectoral fascia passes downward from the clavicle and in-

closes the pectoralis major. The costocoracoid membrane, a still deeper layer of fascia, incloses the pectoralis minor and unites with the deep pectoral to form the axillary fascia lining the base of the axilla. The costocoracoid membrane is continuous with the middle layer of the deep cervical fascia (see Fig. 35). Pus beneath the deep pectoral fascia either travels between it and the costocoracoid membrane to the axilla, or upward into the neck (and anterior mediastinum). Pus beneath the axillary fascia cannot escape toward the surface except upward, on account of the deep pectoral and costocoracoid fasciæ in front, the firm thorax to the inner side, and the arm externally, and the subscapularis behind.

At the outer end of the clavicle, aiding greatly in giving the shoulder its convex outline, is the deltoid muscle, separated from the humerus only by the subdeltoid bursa (see Fig. 41). Between it and the upper edge of the pectoralis major is a groove in which at a superficial level lie the cephalic vein and acromiothoracic artery; at a deeper level lie the coracoid process and pectoralis minor muscle, under which can be found the brachial plexus and the axillary artery and vein.

**The Axilla.**—The skin covering the axilla contains many sebaceous and sweat glands, and is a frequent seat of abscesses of the same. Beneath the superficial fascia is the deep or axillary (see above). The connective tissue of the axilla beneath the fascia is very loose and contains much fat and a large number of lymph-glands, lying chiefly along the vessels, receiving the lymph from the front and back of the chest and from the upper extremity. They are continuous with the deep cervical glands (see Fig. 59). They enlarge in all inflammatory conditions, and in cases of malignant neoplasms occurring in the regions drained by them, and are best examined when the fascia is relaxed, *i. e.*, with the arm brought to side of chest. The course of abscesses resulting from them has been described above.

The intercosto-humeral nerve passes directly through the fat of the axilla. The axillary vein lies in front of the axillary artery (when the arm is extended). It is often double, and thus frequently cut in operations involving the axilla. Above the artery lies the median nerve, below it the ulnar and middle cutaneous nerves, behind it the musculospiral and posterior circumflex nerves (see Fig. 108). From the artery is given off the long thoracic, which, accompanied by the corresponding vein and nerve, lies upon the serratus magnus muscle, supplying it (see Fig. 54). A little more distally the subscapular artery is given off from the axillary. The long thoracic nerve is often severed during operations on the breast unless its position is borne in mind, the result of such injury being a paralysis of the serratus magnus muscle which it supplies. The serratus

magnus, through its attachment along the vertebral border of the scapula, serves to fix the scapula to the chest-wall when the arm is raised. When paralyzed, this function is lost, the vertebral border of the scapula stands out, and there is considerable difficulty in raising the arm. The nerve may be paralyzed independent of any operation, the patient then complaining of being unable to raise the arm as well as before. From its posterior surface the posterior circumflex artery winds around the upper end of the humerus, accompanied by the circumflex nerve. This nerve supplies the deltoid, shoulder-joint, and two teres muscles, and is frequently injured in fractures of the upper end of the humerus, resulting in paralysis of the deltoid with great atrophy (see Figs. 111 and 119). The wasting of the deltoid muscle is extensive after any injury to the shoulder-joint, even a simple sprain, and must be borne in mind in the after-treatment of such injuries. Otherwise the convalescence will be extremely slow.

The vessels and nerves of the axilla lie directly over the lower portion of the shoulder-joint, and are often compressed in subcoracoid dislocation of the humerus (see Fig. 105).

**The shoulder-joint** (see Figs. 41 and 118) is formed by the head of the humerus and the glenoid cavity. The latter is slightly concave and the head of the humerus, which is almost spherical, projects beyond the edge of the joint surface of the glenoid cavity. The joint is crossed in front by the subscapularis muscle as it passes to the lesser tuberosity. To the outer side of this muscle lies the tendon of the long head of the biceps, which runs in a synovial sheath, almost always in communication with the joint (see Fig. 41).

Above, the joint is strengthened by the coracohumeral ligament inserted into the anatomical neck of the humerus. This ligament is firmly adherent to the capsule of the joint and to the supraspinatus tendon lying above it. The joint capsule is strengthened behind by the tendons of the infraspinatus and teres minor, which are firmly ahherent to the capsule. The capsule extends in front as far as the anatomical neck; behind, a little further down (see Fig. 118). The capsule is almost double the volume of the head of the humerus. Its weakest points are between the long head of the biceps and subscapularis above (just below the coracoid process), and also between the subscapularis and teres minor below. When the joint is opened, the biceps tendon, which arises from the upper edge of the glenoid cavity, is seen to pass across the upper surface (Fig. 41). The deltoid muscle lies just over the outer aspect of the joint, covering it like a curtain, separated only by a large subdeltoid bursa (which occasionally communicates with the joint) from the upper end of the

humerus. Hence, when the head of the humerus leaves the glenoid cavity, as in dislocations, the deltoid sinks in, and there is a concavity or depression below the acromion process (see Fig. 105). The arch formed by the acromion and the coracoid processes, and the strong ligaments between them, protect the joint above from direct injury.

The arm can be flexed to a right angle at the shoulder-joint, which action is chiefly carried out by the deltoid; then if the scapula is fixed by the serratus magnus, the arm can be raised almost vertically. The arm can only be extended 70 to 80 degrees (see Fig. 109). It can be adducted only as far as the thorax, but can be abducted with the aid of the scapular muscles almost vertically. The shoulder-joint is frequently the seat of both acute and chronic disease. **Infection** may extend into it from the axilla through the weak points in the capsule, or through the subdeltoid bursa, which the author has seen secondarily involved in infections of the arm. Severe pain is then caused by any movement of the arm, the contour of the shoulder is increased, and the deltoid is expanded by the fluid swelling under it, especially noticeable at its anterior border (see Fig. 59). The axilla also shows a painful swelling. Inflammation of the subdeltoid bursa may simulate this, but there is no swelling in the axilla or pain on movement of the joint. The shoulder-joint is seldom the seat of a chronic process, especially tuberculosis. If the latter affects the joint, abscesses point either in front of or behind the axilla. The shoulder-joint is opened to excise the joint surfaces in tuberculosis, or to drain the same for acute infections. An incision is made from a point midway between the acromion and coracoid processes and the fibers of the deltoid are incised down to the capsule. The cephalic vein and the accompanying artery must be held inward, the long head of the biceps outward. The **upper epiphysis of the humerus** includes the head and the greater part of the tuberosities (see Fig. 118) and the capsule is mainly attached to the epiphysis; hence, in children (see Fig. 116) separation of the upper epiphysis simulates dislocation, and disease in the upper end of the diaphysis does not necessarily involve the cavity of the joint.

**Dislocations of the shoulder-joint** may be either congenital or acquired. The latter are far more frequent.

Dislocation at the shoulder-joint is favored

1. By the fact that the head projects beyond the margins of the glenoid cavity (Fig. 41).

2. The glenoid cavity is very shallow, so that the head of the humerus can readily slip out.

3. The capsule is not strengthened by firm ligaments, but only by

Fig. 118.—Vertical section of shoulder-joint. The right half of the figure represents the posterior half; the left the anterior half. E, Epiphyseal cartilage, between epiphysis (1) and diaphysis (2). 3, Glenoid cavity of scapula, showing its small size as compared with that of the head of the humerus. 4, Acromion process. Above it is seen the outer end of the clavicle. 5, Cavity of shoulder-joint, showing extent of joint surface and synovial membrane. 6, Brachial vessels and nerves.

muscles or tendons, being protected above by the acromioclavicular arch.

4. In falls upon the upper extremity, in order to break the force of the injury, the arm is abducted so that the head of the humerus is brought in contact with the weakest part of the capsule (the inferior), and escapes toward the axilla, and then, by the action of the pectoral muscles, is most frequently pulled forward, so that it rests under the coracoid process. If the force is applied from the front, the head may be pulled backward by the scapular muscles.

In all varieties of dislocations the normal contour of the shoulder is absent, there is a concavity or depression below the acromion, the axis of the humerus is changed, and the arm is lengthened (see Fig. 105). The arm is flexed by the biceps and abducted by the deltoid. In the subcoracoid variety (the most frequent) the head can be felt just below the outer end of the clavicle. There is rigidity at the shoulder-joint. In the subglenoid variety the head of the bone is felt in the axilla, resting against the outer border of the scapula, and there is marked abduction of the arm.

In **subcoracoid dislocation** the subscapularis muscle is stretched over the head of the bone, the supraspinatus and infraspinatus and teres minor are very tense, and may be torn.

The axillary vessels and brachial plexus lie between the chest-wall and the head of the humerus, and are apt to be compressed if the dislocation is not recognized. Kocher's method of reduction depends upon the fact that (*a*) when the arm which has been adducted until the elbow touches the side is rotated outward, the capsule and muscles are stretched, allowing the rent in the capsule to gape; (*b*) when the arm is elevated, the head is brought opposite the rent and the arm being carried toward the opposite shoulder allows the head to slip back into the glenoid cavity.

For a description of the other varieties of dislocation and their reduction, see books on fractures, etc.

**Fractures of the Upper End of the Humerus.**—These may be:

1. Fracture of the anatomical neck (chiefly in old people).
2. Separation of the upper epiphysis (up to the twentieth year).
3. Fracture of the surgical neck.

In order to examine the upper end of the humerus, it should be grasped between the fingers and thumb of one hand, press in front of and behind the deltoid, the elbow being held flexed in the palm of the other hand. By moving the humerus in different directions crepitus and

false point of motion (unless the fracture is an impacted one) can be readily obtained. The length of the humerus should be measured from the acromion to the external condyle (see Fig. 107). If the head rotates with the shaft, there is probably no fracture. If it does not, there is.

1. *Fracture of the Anatomic Neck.*—This is an intracapsular fracture, always due to falls or blows on the shoulder. The latter is swollen, the head of the humerus is felt to be irregular, and crepitus can be obtained unless there is impaction.

2. *Separation of the Upper Epiphysis.*—The upper epiphysis (Fig. 116) joins the shaft at the age of twenty. Before that time the shaft may be torn almost horizontally across, below the epiphyseal cartilage, the epiphysis itself being often rotated so that its articular surface looks downward and the lower fragment is felt just below the coracoid, being pulled upward and inward by the pectoral muscles.

3. *Fractures of the Surgical Neck* (see Fig. 119).—These include all fractures below the epiphyseal line, situated in the upper fourth of the bone. They usually result from blows on the shoulder or falls on the hand or elbow. The fracture is usually transverse, the lower fragment is drawn inward by the pectoral muscles, and upward by the biceps, triceps, deltoid, and coracobrachialis. The upper fragment is rotated outward by the muscles attached to the tuberosities and adducted by the subscapularis. It may leave the glenoid cavity completely. On account of the fact that the circumflex nerve passes around the shaft of the humerus, it may be greatly stretched or torn in dislocations of the shoulder, or may be torn or caught between the fragments in a fracture of the surgical neck with resultant paralysis of the deltoid muscle. In this fracture there is always a depression just below the shoulder, but not such a marked loss in its contour as in a dislocation.

## Scapular Region.

The skin of this region is firmer than that of the remainder of the shoulder. The subcutaneous tissue is frequently the seat of lipomata. As far as the spine, the upper portion of the scapula is covered by the trapezius, beneath which is the supraspinatus muscle in the corresponding fossa, which passes across to the greater tuberosity of the humerus. The fossa below the spine is to be more distinctly palpated. It is filled out by the infraspinatus and teres minor, which pass across to the tuberosity of the humerus. The insertion of these muscles is covered by the deltoid, and between the latter and the neck (surgical) of the humerus at this point the posterior circumflex artery and circumflex nerve lie, passing backward from the axilla and then curving around

Fig. 119.—Dissection of a fracture of surgical neck of the humerus (modified from Helferich and Hoffa), showing how the circumflex nerve as it winds around the posterior aspect of the surgical neck of the humerus may be caught in the callus; also showing the change in the contour of the shoulder.

the upper end of the humerus (see Fig. 111). On the anterior surface of the scapula lies the subscapularis muscle, which passes across the front of the shoulder-joint, forming in part the posterior wall of the axilla. Fracture of the body of the scapula is very rare, and usually due to direct violence. Fracture of the acromion is most frequent, that of the body or neck being very rare. If the acromion is broken, the shoulder is flattened. Crepitus may at times be felt. Fracture of the neck of the spine of the scapula may be mistaken for a dislocation. The arm is lengthened, but on lifting it the deformity is corrected and crepitus is detected; but if this upward pressure is removed, the deformity recurs.

## Brachial or Upper Arm Region.

The **skin** is fine on the anterior, coarser on the posterior aspect. It is very movable, adapting itself readily to plastic operations. In the subcutaneous tissue, which does not contain much fat, there are many veins, emptying on the outer side into the cephalic vein and on the inner into the basilic vein. Both of these larger veins lie in this layer, the cephalic in the groove to the outer side, the basilic in that on the inner side of the biceps muscle (see Fig. 56). There are many subcutaneous lymphatic vessels lying principally along the inner side of the arm and emptying into the axillary glands (see Fig. 59). The superficial nerves are derived from the circumflex, intercosto-humeral, internal cutaneous, and musculospiral above the elbow (Fig. 23). Beneath the subcutaneous tissue is a fascia thin in front, firmer behind. It is continuous above with the axillary and along the inner and outer aspect of the arm it passes inward to the humerus, forming an internal and an external intermuscular septum, thus dividing the arm into an anterior compartment, containing the median nerve, brachial artery and veins, brachialis anticus, biceps, and the coracobrachialis muscles; and a posterior compartment, containing the triceps, the musculospiral nerve, and superior profunda artery (see Fig. 120). The **ulnar nerve** lies at first to the inner side of the median nerve in the anterior compartment (Fig. 120), penetrates the internal intermuscular septum lower down, and lies in the posterior compartment (see Fig. 108). The **brachial artery** begins at the point of insertion of the pectoralis major, runs along the inner side of the biceps to the bend of the elbow, where it divides into the ulnar and radial arteries. Its largest branch (the superior profunda) accompanies the musculospiral nerve (see Fig. 120). The brachial may divide into the above two vessels higher up (middle third of arm), one artery lying in front of, the other behind, the median nerve. The **median nerve** normally lies to the outer side of

the artery in the upper third, then in front of it (middle third), and below (lower third) it crosses the artery lying to the inner side. When an artery is found in front of it, a larger one must be looked for behind it.

The **musculocutaneous** nerve leaves the brachial artery opposite the middle of the coracobrachialis, passes between this muscle and the biceps to the external condyle.

The ulnar nerve lies to the inner side of the brachial artery in the upper third of the arm (Fig. 120); it then pierces the internal intermuscular septum to reach the internal condyle, passing between the latter and the olecranon (Fig. 113), joining the ulnar artery a little below the bend of the elbow (Fig. 110).

The **musculospiral nerve,** accompanied by the superior profunda artery, leaves the upper part of the brachial artery, winds around the shaft of the humerus between the triceps and the bone (Fig. 109), piercing the external intermuscular septum just above the external condyle. At this point it divides into the posterior interosseous and radial nerves. In amputations it must be cut by the knife straight across with the bone, or else it will be torn by the saw. In such **amputation at the middle of the upper arm,** the anterior flap contains the brachial vessels, median nerve, biceps, coracobrachialis, and brachialis anticus muscles; the posterior flap contains the ulnar and musculospiral nerves, the superior profunda artery, and the triceps muscle (see Fig. 120). Further down, near the elbow, the musculospiral would lie in the anterior flap.

The best points to test the painfulness of the nerves of the brachial region in cases of neuritis are the outer aspect of the middle of the shaft of the humerus for the musculospiral, the groove between the internal condyle and the olecranon for the ulnar nerve, and pressure over the external condyle for the radial nerve. The main trunks of the ulnar and median can be pressed upon close to the axilla along the inner border of the biceps.

**Fracture of the Shaft of the Humerus.**—Is most frequent at the middle third of the bone. There is usually but little, if any, displacement. The deltoid and pectoralis major muscles may pull the upper fragment upward and inward; the triceps, the lower fragment backward (see Fig. 122).

These fractures are of interest on account of the frequency with which the musculospiral nerve is injured at the time of the accident, either torn across by the original violence or lacerated by the ends of the fragments; occasionally it is included in the callus. Such injury

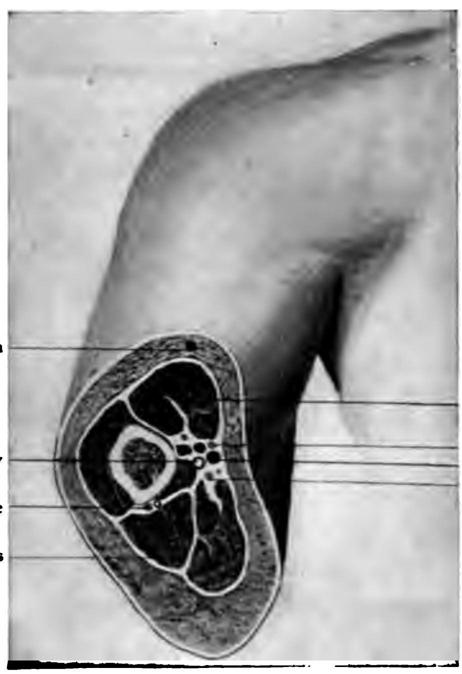


Fig. 120.—Cross-section at middle of arm.

Fig. 121.—Wrist-drop, due to pressure paralysis of the musculospiral nerve, usually through being involved in a callus or caught between fragments in a fracture at the middle of the shaft of the humerus. In this case it followed too tight an application of an Esmarch constrictor.

gives rise to the characteristic wrist-drop (paralysis of the extensors of the forearm and wrist) and anesthesia of the radial side of the forearm and fingers (see Fig. 130). Fractures of the shaft are of interest also on account of the frequency of non-union. This is frequently due to the lack of support to the elbow, allowing too much motion, and also to the interposition of muscle.

## The Elbow Region.

The surface anatomy has been given above. The skin of the anterior surface is thin, that of the posterior much thicker. Just beneath the skin, in front, lie the **veins** spoken of under the examination of the living arm (Figs. 114 and 56), the median vein, as it returns from the forearm, dividing at the bend of the elbow into the median basilic which unites with the ulnar vein to form the basilic vein, and the median cephalic, which unites with the radial vein to form the cephalic. Smaller veins pass through the fascia which serve to connect these superficial with the deep veins. In phlebotomy at the elbow the median basilic is most frequently opened, the arm being compressed above to render it more prominent. The superficial **lymphatics** accompany the veins and are most numerous over the inner condyle, emptying into the cubital glands situated just above this prominence (Fig. 59). In infections of the ulnar side of the forearm or hand this gland is affected, while in those of the radial side the infected lymph is carried directly to the axillary glands (Figs. 59 and 60). The superficial **nerves** in front are the internal and external cutaneous; behind, the cutaneous branches of the musculo-spiral and intercosto-humeral nerves (Fig. 23). In front of the elbow the fascia is strengthened by the bicipital fascia, an aponeurosis covering the brachial artery and median nerve, continuous with the biceps. Beneath the bicipital fascia the brachial artery lies in front of the joint, to the inner side of the biceps tendon, dividing beneath the bicipital fascia into the radial, lying more superficially, and the ulnar. At this point, aneurisms of the brachial not infrequently occur, and it is important to bear in mind that the radial, soon after its origin, gives off a recurrent branch which anastomoses with the superior profunda artery, a branch of the brachial. When the elbow is flexed, the brachial artery is compressed; hence, to judge of the quality of a patient's radial pulse, the arm should always be straightened. The muscular prominence to be seen and felt through the skin on the inner side of the biceps tendon is formed by the pronator radii teres, the flexor carpi ulnaris, palmaris longus, and flexor carpi radialis. The prominence on the outer side is formed by the supinator longus, beneath which lie the extensors.

On the posterior aspect of the elbow is seen the triceps tendon, inserted into the olecranon process. Between the latter and the skin is the olecranon bursa, which frequently inflames after a fall upon the elbow (see Fig. 113). To either side of the olecranon process is a depression normally which is obliterated in cases of effusion in the joint (see Fig. 59). This is the first place at which a synovitis with fluid exudate shows itself and the elbow-joint can best be drained and explored through the outer depression. Over the inner of these depressions lie the anastomoses of the ulnar recurrent artery with the brachial artery, which assist in establishing a collateral circulation. In this inner space lies the ulnar nerve, which must be avoided in resection of the elbow. For the same reason exploratory puncture is best made through the outer space or depression. The **elbow-joint** is formed by the articular surfaces of the lower end of the humerus and of the upper ends of the radius and ulna (see Fig. 123). The humerus and ulna form a firm hinge-joint in which only flexion and extension are possible, being especially strengthened by the olecranon posteriorly. The humerus and radius form a ball-and-socket joint in which free movement is possible, notably extension and flexion, but also rotation. The joint between the radius and ulna permits only of rotary movements. The elbow-joint capsule is thin, especially posteriorly over the olecranon fossa. It is greatly strengthened laterally by ligaments, but in front and behind is quite weak. For this reason antero-posterior dislocations are quite common, lateral are rare. The forward dislocation occurs when the arm is strongly flexed, the olecranon sliding forward on the anterior surface of the joint. Backward dislocations (Fig. 124) are the most common, being frequently associated with fracture of the coronoid process of the ulna. They occur during hyperextension (falls on outstretched hand), the coronoid slipping across the articular surface.

**Fractures of the Elbow.**—The most important point in the examination of the elbow is to determine the relations of the three bony prominences, the condyles and olecranon, to each other (see Fig. 113), and also to determine whether the movements of the radius upon the humerus, as felt just below the external condyle, are normal. When the elbow is flexed, these three bony landmarks form a triangle, the olecranon being ½ inch lower. When the elbow is extended, they lie in one line (see Fig. 113). These were referred to under Examination of Upper Extremity during Life. The most frequent form of injury is either a dislocation backward of both bones of the forearm, or a fracture of the humerus above the condyles (especially in children). For systematic examination it is best to remember that one of the following conditions

Lesions of Radius and Ulna.

(*a*) Dislocation of the radius and ulna backward, with or without fracture of the coronoid process.
(*b*) Subluxation of the radial head (in children).
(*c*) Fracture of olecranon process.
(*d*) Fracture of head or neck of radius.

Lesions of Lower End of Humerus.

(*a*) Fracture of internal epicondyle.
(*b*) Fracture of internal condyle.
(*c*) Fracture of external condyle.
(*d*) Supracondyloid fracture (transverse).
(*e*) Separation of lower epiphysis.
(*f*) Transverse fracture into elbow-joint—T or Y.

Ankylosis is very apt to follow after any injury to the elbow, even a simple sprain, unless great care is exercised to establish early passive motion.

**Dislocations of the Elbow.**—These may be in one of four directions, but are by far more frequent backward, involving both radius and ulna. The reason why backward dislocation of these bones is the most frequent is that the accident which causes it is a fall upon the outstretched arm, the hand being held in a prone position. The result is a forcible abduction and extension, the coronoid process either breaks off or slips over the lower end of the humerus without being broken. The addition of violence transmitted along the forearm forces the ulna and radius over the posterior aspect of the joint surface of the humerus.

In these cases the forearm is shortened. The olecranon is situated above the line drawn between the two condyles and one can feel the inner margin of the greater sigmoid cavity. Externally the head of the radius can be felt close behind the external condyle.

There may be a dislocation of either radius or ulna alone; that of the former is more frequent, and of this the forward variety. The mode of production is not clear. It is due either to direct violence or to excessive pronation combined with traction. A similar dislocation occurs in children, but is an incomplete one (subluxation). There is no change in the relations of the bones. Passive motion is free, but painful, except supination. On forced supination a slight click is heard. The injury consists in the escape of the head of the radius below the orbicular ligament. It is produced by traction and adduction of the extended forearm in children.

**Fractures of the Olecranon Process.**—These are usually due to

direct violence and are transverse about the middle of the process. There is usually considerable separation of the fragments, the upper being pulled upward by the triceps muscle. The fragments are brought closer together when the arm is extended. There is usually great swelling of the elbow, the fracture opening into the joint (Fig. 124).

**Fracture of the Neck or Head of the Radius.**—Very uncommon. There is swelling over radial head and neck, and loss of rotation of same.

**Fractures at Lower End of Humerus.**—The **supracondyloid fracture** is the most common, especially in young persons (Fig. 122). The fracture is transverse above the olecranon fossa and is most frequently due to a fall upon the elbow. The front of the elbow is fuller on account of the upper fragment being displaced forward. The three bony points maintain their relations. Abnormal lateral and antero-posterior mobility and crepitus are found above the elbow-joint.

**The T-shaped fracture and separation of the epiphysis** resemble greatly the former (the epiphyseal fracture occurring under ten years) (Fig. 116). In the T-shaped fractures the relations of the bony points will be changed, according as one or both condyles are displaced.

**Fracture of Internal Epicondyle.**—(Tip of internal condyle.) Is quite common in infants. There is but little displacement. If the fragment is small, it is of little consequence.

**Fracture of the Internal Condyle.**—The inner of the three bony points is displaced upward. The line of separation passes into the joint. The fragment is often displaced upward and may give rise to a gunstock deformity.

**Fracture of the External Condyle.**—The normal relations of the three bony points are disturbed. External condyle displaced upward.

**Diseases of the Elbow-joint.**—This joint is frequently the seat of both acute and chronic synovitis; of the former, the rheumatic and purulent, of the latter the tubercular variety. The presence of an effusion in the joint first shows itself by a bulging to both sides of and above the olecranon; less frequently over the radio-humeral articulation (see Fig. 59). If sinuses due to spontaneous discharge of the effusion are present, they are most often situated to either side of the triceps tendon. The limb is held flexed, usually midway between pronation and supination.


Fig. 122.– Dissection on the right arm of a supracondyloid fracture of the humerus showing the backward displacement of the lower fragment by the triceps. On the left arm is shown a fracture in the middle of the shaft of the humerus showing how the musculospiral nerve may be included in a callus or between the fragments.

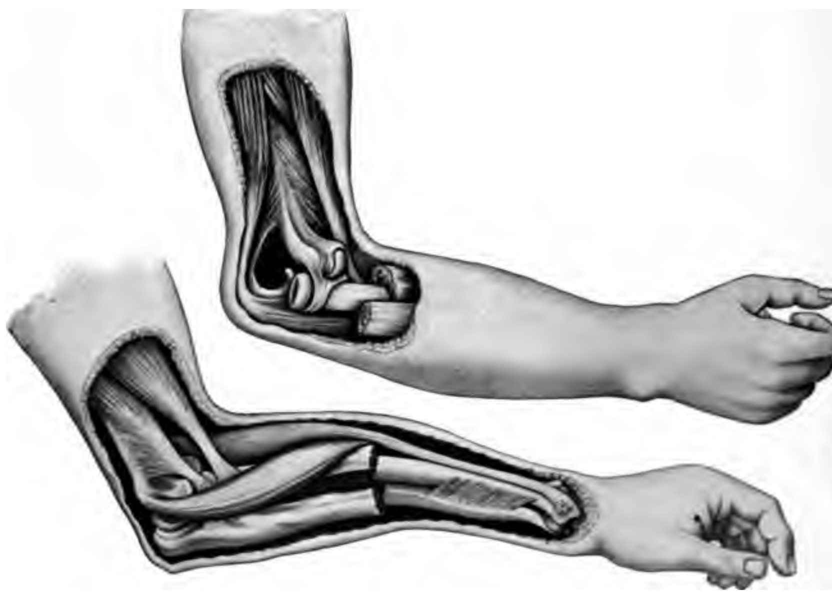

Fig. 123.—Backward dislocation of both bones of the elbow and fracture of both bones of the forearm (modified from Helferich and Hoffa). The upper of the two figures shows a backward dislocation at the elbow-joint, both bones being involved, showing the prominence on the back of the elbow in this form of dislocation. The lower of the two illustrations is a fracture of both bones of the forearm in the middle third, showing the action of the pronator radii teres in rotating the upper fragment of the radius, of the pronator quadratus in approximating the two bones, and of the brachialis anticus and biceps in pulling the upper fragments upward and forward.

**The Forearm.**

The surface anatomy and markings were given above. The skin on the anterior surface is thin, that on the posterior thicker and less movable. In the subcutaneous tissue can be seen on the anterior surface a rich network of veins and lymphatics. The veins form one large trunk along the radial border—the *radial vein;* one along the middle—the *median;* and a third along the ulnar side—the *ulnar.* Their relation to each other at the elbow has been given under the anatomy of the elbow region. The lymphatics, which are most marked on the ulnar border anteriorly, pass to the cubital gland (see Fig. 59). Those on the back of the forearm pass across to the front of the elbow at the level of the latter. The fascia is firmly attached to the posterior border of the ulna in its entire length, and in its lower third to the outer border of the radius, thus dividing the forearm, with the aid of the interosseous membrane, into two compartments in its lower third (see Fig. 115). The superficial nerves are derived from the external and internal cutaneous (Fig. 23). Of the muscles of the forearm, the pronator radii teres may be strained and cause a painful swelling to appear in the upper third of the anterior aspect of the arm. The tendon-sheaths of the extensors of the thumbs are liable to become inflamed, causing a swelling to appear which runs obliquely from the base of the thumb across the back of the lower third of the forearm, giving rise at first, upon extension of the thumb, to a creaking sensation (Figs. 59 and 125).

**Arteries.**—The radial and ulnar arteries arise from the brachial, just below the elbow (Fig. 110). The **ulnar** lies very deep below the muscles on that side of the forearm, lying a little more superficially lower down (Fig. 114). Just above the wrist it lies to the radial side of the ulnar nerve and tendon of the flexor carpi ulnaris (Fig. 115). Instead of arising from the brachial at the elbow, it may be given off from the same artery in the arm, or even arise from the axillary. It may run quite superficial, close to the veins of the elbow.

The **radial artery** also arises from the brachial, passing across the pronator radii teres, and becomes quite superficial, lying to the radial side of the flexor carpi radialis. The main artery may pass across to the back of the thumb, so that a small vessel may take its place as the one felt for as the radial pulse, leading to deception in regard to its quality. There is a very free anastomosis between the two arteries on the front of the forearm. The back of the arm is but scantily supplied with vessels. Wounds of the same are less dangerous and it adapts itself well for the administration of hypodermic injections.

**Nerves.**—The **ulnar nerve** lies to the ulnar or inner side of the

ulnar artery in its entire course (Figs. 108, 110, and 114). The **radial nerve** lies to the radial or outer side of the radial artery. The **median nerve** passes between the two heads of the pronator radii teres, lying upon the deep flexors until just above the wrist, where it becomes quite superficial; it lies between the tendons of the flexor carpi radialis and those of the flexor sublimis, and is very likely to be injured here (see Figs. 110, 114, 115, and 126).

**Fractures of the Forearm.**—The most frequent seats are either in the middle or lower thirds of the bones (Fig. 124). They may be complete or incomplete (greenstick). Fracture of the shaft of the ulna usually occurs as the result of direct violence, and on account of its close relation to the skin, the fracture is often compound. Fractures of the shaft of the radius are more common than those of the ulna, and are also due to direct violence. When the fracture is above the insertion of the pronator radii teres, the upper fragment of the radius is often pulled upward by the biceps; hence in such cases the arm should be placed in a supine position. In other fractures of one or both bones the arm should be placed midway between pronation and supination, the bones then being parallel, and the space between them well padded in order to prevent the pronators pulling them toward each other. On account of the fact that the bulk of the blood is returned by the surface veins chiefly, great care must be exercised so as not to apply the bandage too tightly, cases of gangrene having been reported.

The space between the radius and ulna is greatest when the arm is held in a position midway between supination and pronation, and in this position the radius and ulna are least likely to become adherent to each other. A study of figure 114 will show the relations at the upper third of the forearm.

## The Wrist and Hand.

The surface anatomy and markings have been given on page 369. The skin of the palm of the hand and flexor surfaces of the fingers is thick; the subcutaneous tissue is composed of closely arranged bundles of connective tissue, inclosing lobuli of fat. The skin on the back of the hand is much thinner and the subcutaneous tissue more loosely arranged. For these reasons, swelling due to injury, infection, or general diseases (nephritis) shows itself more readily on the back of the hand. The palm of the hand, fronts and sides of the fingers, and dorsal aspects of the last phalanges all show an absence of hair and sebaceous glands; hence furuncles seldom have their starting-point here, but are more frequent on the dorsum of the hand and of the first and second rows of phalanges, where there are numerous hairs and sebaceous follicles.

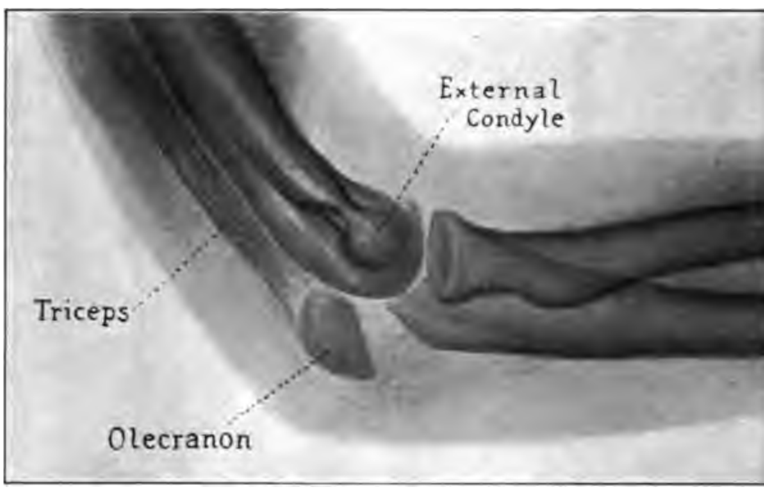


Fig. 124.—Fracture of olecranon, showing how upper fragment is pulled upward by triceps. Made from *x*-ray.

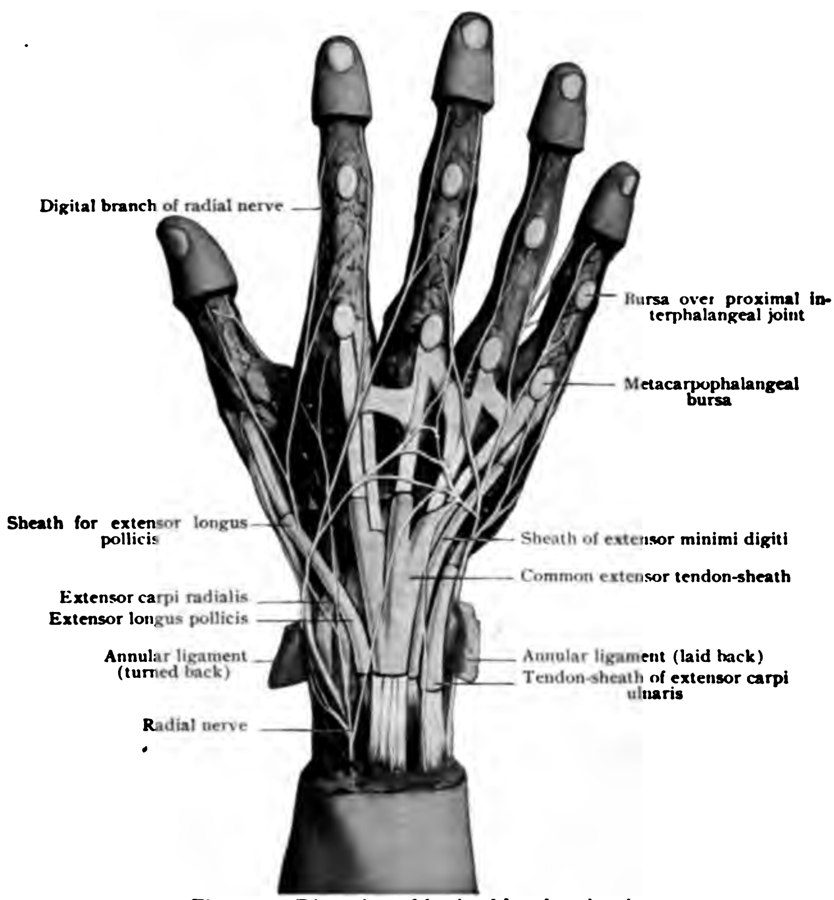


Fig. 125.—Dissection of back of hand and wrist.

In the subcutaneous tissue there are many lymphatics, nerves, and blood-vessels. On the back of the hand the **veins** form a rich superficial network; over the palm they are very deeply situated. The **lymphatics** on the flexor surface of the fingers run at right angles from the skin toward the periosteum; hence infection from needle-pricks, etc., is rapidly carried to the latter, causing a felon or suppurative periostitis (see Fig. 129) of one of the phalanges, usually the most distal or ungual. The lymphatics from the ulnar side of the hand accompany the ulnar vein to the elbow, emptying into the cubital and axillary glands (Figs. 59 and 60); those from the radial side and back part of the hand accompany the radial veins to the bend of the elbow, emptying partly into the cubital, but chiefly into the axillary glands (Fig. 59). For these reasons a lymphangitis or inflammation of a lymph-vessel which follows an infection of the radial side of the hand travels directly to the axillary glands, while on the ulnar side it travels to the cubital.

The fascia at the wrist, both in front and behind, forms a strong fibrous band (Figs. 125 and 126) (annular ligament) which arches over the carpus beneath, and in the compartments of which the flexor tendons lie on the front, and the extensor tendons on the back of the wrist (Fig. 115). It is continuous with the firm fascia of the palm of the hand (palmar).

**The Palmar Fascia.**—This is a strong fibrous layer firmly attached to the skin of the palm and to the annular ligament. Opposite the metacarpo-phalangeal joint of each finger, it gives off two slips which are attached to the sides of the joint and allow the flexor tendons to pass between them. Between the slips of adjacent fingers lie the digital arteries and nerves. The palmar fascia in diseased conditions, especially that of the last two fingers (Dupuytren's contraction), is apt to be greatly thickened, causing a flexion of those fingers. On account of its great density, it prevents pus from escaping to the surface and causes it to escape between the metacarpal bones toward the back of the hand, or along the tendon-sheaths into the forearm. Beneath the fascia lie the superficial and deep palmar arches and the branches of the median and ulnar nerves (Figs. 110 and 126).

**Flexor and Extensor Tendon-sheaths.**—For the flexor tendons we may speak of two proximal sheaths, one for the deep and superficial flexor tendons of the fingers in common (Figs. 110, 115, and 126,) which begins about 1½ inches above the annular ligament, passes beneath the same, and ends about the middle of the palm of the hand; the other takes the same course, but incloses only the flexor longus pollicis, and is con-

tinuous with the distal portion of the same. The distal flexor synovial sheaths consist of one for each finger, extending from opposite the head of the metacarpal bone to the middle of the last phalanx (Figs. 110 and 126). Those for the index, middle, and ring fingers communicate with each other, while that for the little finger frequently communicates with the common flexor sheath in the palm of the hand. On the back of the hand there is only a proximal common extensor sheath, beginning about two inches above the wrist and extending down to the middle of the back of the hand (see Figs. 60 and 125). The extensor tendons on the back of the fingers have no tendon-sheath. Infection can travel rapidly along the lymphatics of the flexor or front surface of the fingers, penetrate the tendon-sheaths, and pass to the palm of the hand. In infection of the thumb and little finger organisms can travel direct to the forearm, giving rise to serious intermuscular phlegmons. These sheaths may be the seat of a tubercular inflammation, giving rise to fluctuating swellings along their normal situation. The **nails** receive their nourishment chiefly at the matrix or base of each nail, and if this is injured, the entire distal portion of the nail is destroyed.

**Wrist-joint.**—Its strength depends mainly upon the strong tendons which surround it and also the strong ligaments which bind the carpal bones together. It is rarely dislocated, and if so, the posterior form is more common, on account of the greater strength of the anterior ligament and the fact that dislocation occurs through a fall upon the outstretched hand. Effusion due to disease of the joint shows itself by a swelling on the back of the wrist (Fig. 60), and is apt to extend to the intercarpal joints and to the adjacent tendon-sheaths. A circumscribed swelling, commonly called ganglion, or weeping sinew, may appear at the back of the wrist, or even on the front of the same, or along any of the tendon-sheaths. It is usually a hernial protrusion from the tendon-sheath, or a similar condition of the synovial membrane of the wrist-joint. The anatomical fact that these ganglia communicate frequently with the wrist-joint should be borne in mind; it should also be remembered that they are frequently tubercular, so that an indiscriminate scattering of the same by means of a book, etc., as recommended by some, may be followed by a serious tuberculosis of the wrist-joint on account of this communication. An inflammation of the tendon-sheaths may be either of an acute or a chronic nature. If acute, it gives rise to pain and swelling along the line of the tendon-sheath, and often to a sensation of crepitation (tendo-vaginitis-crepitans). Such inflammations, both acute and chronic, are likely to appear in those who use the hands extensively—artists, pianists, machinists, etc. The relation of the

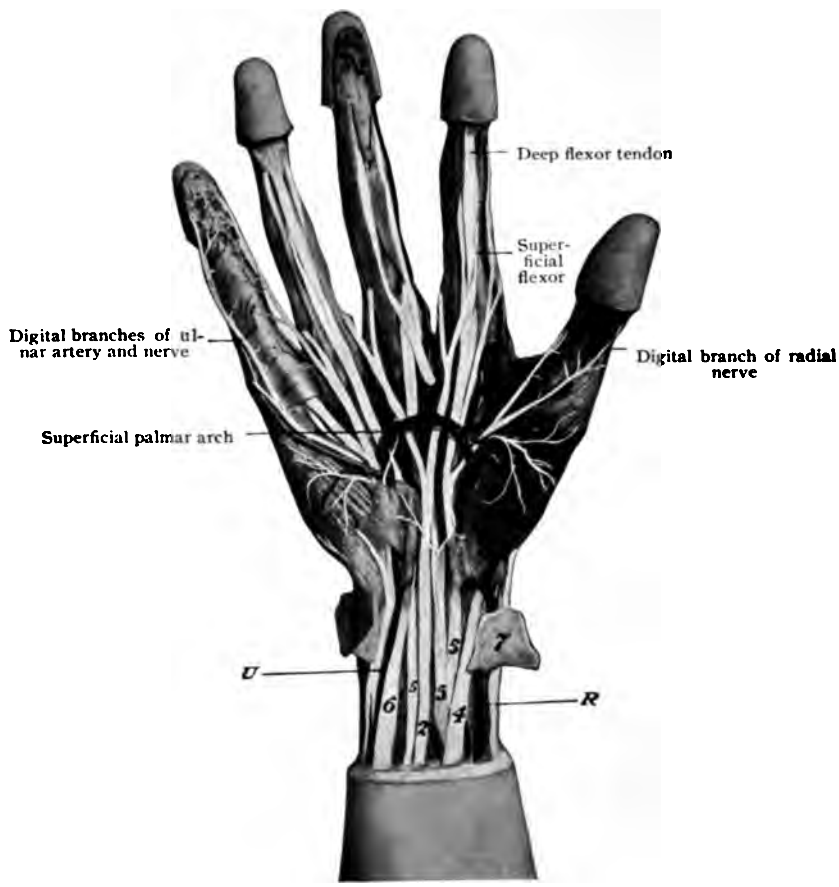


Fig. 126.—Dissection of front of hand. 2, Median nerve. 4, Flexor carpi radialis tendon. 5, Superficial and deep flexor tendons. 6, Flexor carpi ulnaris tendon. 7, Annular ligament turned back. U, Ulnar artery lying upon ulnar side of flexor carpi ulnaris tendon (6). Upon its inner (ulnar) side lies the ulnar nerve (white band). R, Radial artery, lying on radial side of flexor carpi radialis tendon (4). Upon its outer side lies the radial nerve.

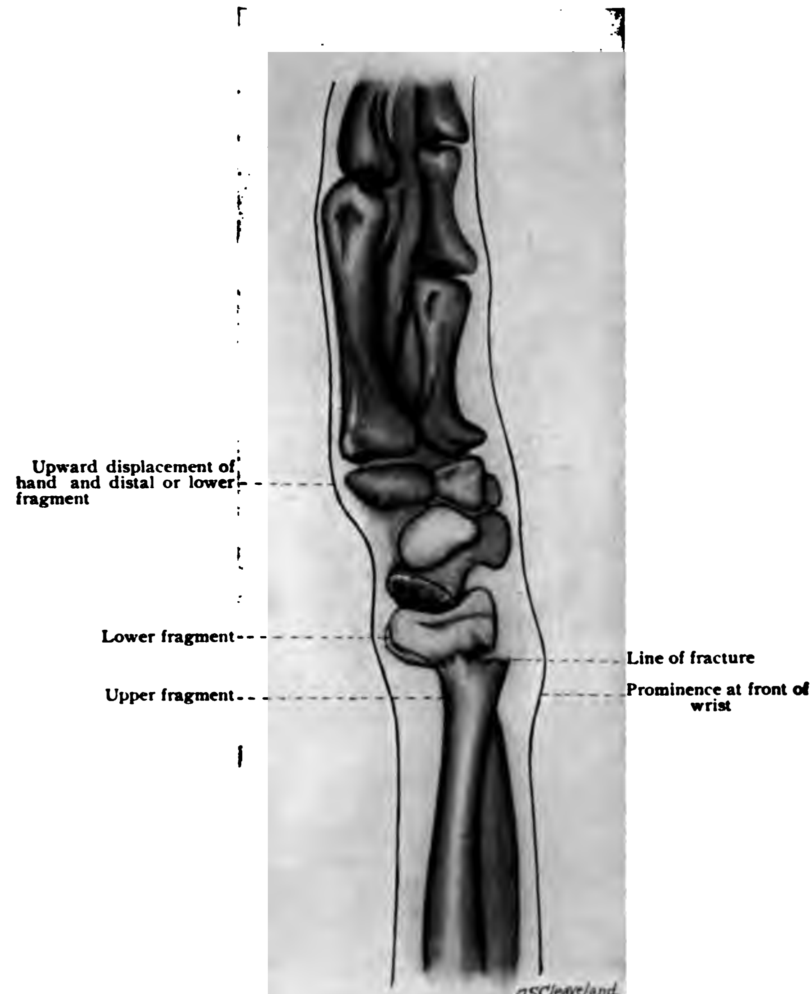


**Fig.** 127.—Colles' fracture. Lateral view. Showing upward displacement of lower fragment, giving rise to silver-fork deformity. Made from $x$-ray picture.

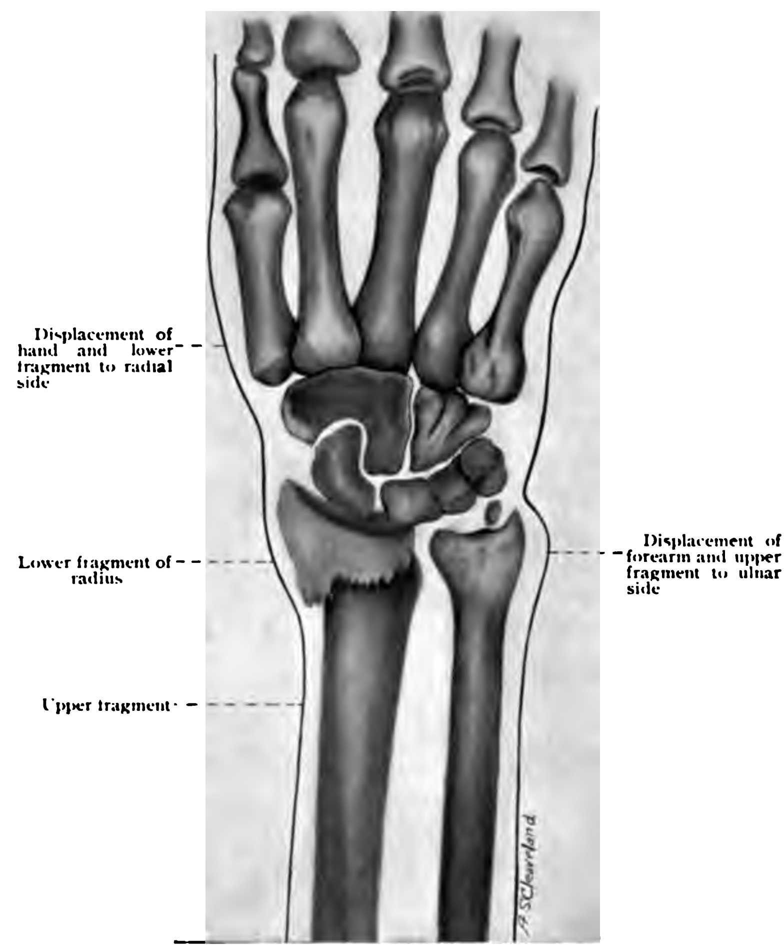


Fig. 128.—Colles' fracture. View from above, showing displacement of lower fragment and hand toward radial side. Made from $x$-ray picture.

tendons and vessels at the front and back of the wrist to each other can be best understood by a study of figure 115.

**Colles' Fracture.**—This is a fracture of the lower end of the radius, occurring in adults about one inch above the articular surface (Figs. 127 and 128). In children an incomplete fracture may exist at about the same point, due to separation of the lower epiphysis of the radius (see Fig. 115). Colles' fracture is usually transverse and due to a fall upon the outstretched hand. There may be great displacement of the lower fragment, usually upward and outward, with displacement of the upper fragment and entire ulnar side of the arm downward and inward, so that the hand is carried to the radial side and backward. The ulna is more prominent in front of the wrist and to its inner side.

The **superficial palmar arch,** as well as the deep palmar arch, lie within the limits of a letter M which the creases on the palm of the hand form (see Fig. 110). The ulnar and median nerves also lie here (Fig. 126), giving off their digital branches to run along the lateral aspect of each finger. Incisions to relieve suppuration in the fingers should, if possible, be made midway between the tendon-sheath and the lateral aspect of the finger, so as to avoid opening the sheath and injuring the digital nerves and vessels.

## Paralysis of the Nerves of the Brachial Plexus.

1. **Circumflex.**—The effect of a paralysis of this nerve was spoken of in relation to fractures of the surgical neck of the humerus (see

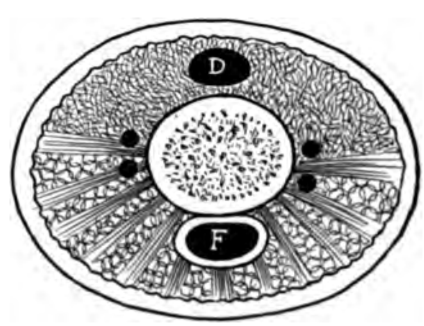


Fig. 129.—Cross-section of finger (diagrammatic). F, Flexor tendon in sheath. D, Extensor tendon. The digital nerves and arteries are seen lateral to the bone. Note the arrangement of connective tissue on palmar and dorsal surfaces, at right angles to bone in former.

Fig. 119). The resulting inability to use the deltoid renders it impossible for the patient to raise (abduct) the arm, and causes a rapid atrophy of the fibers of the muscle (loss of normal convex outline of shoulder).

**2. Musculospiral and its Continuation (Radial and Posterior Interosseous).**—This has been referred to in relation to fractures of the middle of the shaft of the humerus (see Fig. 122). In addition to its frequent injury in fractures at this point, it is also paralyzed as the result of pressure of the head upon the nerve over the outer condyle during deep sleep (especially in alcoholics). Another frequent cause of paralysis of this nerve is lead-poisoning, producing one of its most striking symptoms (Fig. 130), known as "drop-wrist." In paralysis of this nerve the following movements cannot be carried out:

| Movements Lost. | Muscles Paralyzed. |
|---|---|
| (*a*) Extension of forearm, *i. e.*, of elbow-joint. | Triceps. |
| (*b*) Flexion of elbow when midway between supination and pronation. | Supinator Longus. |
| (*c*) Supination of forearm. | Supinator Brevis. |
| (*d*) Extension of wrist (raising it). | Extensor Carpi Radialis longior et brevior. Extensor Carpi Ulnaris. |
| (*e*) Extension of fingers. | Extensor Communis Digitorum. |
| (*f*) No extension, and only imperfect adduction of thumb. | Extensor Pollicis longus et brevis. |

In addition, there is rapid atrophy of the extensor muscles (back of the forearm), and anesthesia of the posterior aspect of the arm, forearm, and thumb, index-finger and outer margin of middle finger.

**3. Paralysis of the ulnar nerve** is a frequent accompaniment of progressive muscular atrophy. It causes a characteristic deformity of the hand, known as the "claw hand" (*main en griffe*), shown in figure 131. The following movements cannot be carried out:

| Movements Lost. | Muscles Paralyzed. |
|---|---|
| (*a*) Adduction of hand, *i. e.*, toward ulnar side. | Flexor Carpi Ulnaris. |
| (*b*) Flexion of first phalanges of fingers and extension of middle and end phalanges. | Interossei and Lumbricales. |
| (*c*) Adduction of thumb. | Adductor Pollicis. |

The claw-hand deformity is due to the fact that the antagonists of the interossei and lumbricales, the extensors and flexors (when nerve is affected in forearm after nerve for flexors has been given off), extend the first and flex the middle and end phalanges (see Fig. 131).

These paralyses of motion are accompanied by anesthesia of the ulnar side of the palmar and dorsal surfaces of the hand and little finger, and ulnar half of the middle finger (see Fig. 131).

Fig. 130.—Drop-wrist following paralysis of the musculospiral nerve (Leube).

Fig. 131.—Claw-hand (main en griffe) following ulnar paralysis (Leube). (See page 410.)

### 4. Paralysis of the Median Nerve.—

| Movements Lost. | Muscles Paralyzed. |
|---|---|
| (*a*) Inability to pronate forearm. | Pronator Radii Teres and Pronator Quadratus. |
| (*b*) Abduction of hand (bending it to radial side). | Flexor Carpi Radialis. |
| (*c*) Flexion of end phalanges (index and middle fingers). | Flexor Profundus Digitorum (outer half). |
| (*d*) Flexion of middle phalanges of all fingers. | Flexor Sublimis Digitorum. |
| (*e*) Flexion and abduction of thumb. | Abductor pollicis and Opponens pollicis. |

These are accompanied by anesthesia of the palmar surface of the thumb, index, middle, and radial side of the ring finger.

Combinations of these paralyses can exist after any injury to, or pressure upon, the brachial plexus, such as dislocation of shoulder, tumors, obstetric (Duchenne, Erb) paralysis, etc., or in spinal cord diseases.

# LOWER EXTREMITY.

**Examination during Life.**—Note the division (arbitrarily made) of the lower extremity into the buttock, or hip region, the thigh, the leg, and the foot. The **hip region** extends from the crest of the ilium to the gluteal fold (see Fig. 51). The **thigh region** embraces the greater part of the femur and its surrounding structures, from the inguinal fold in front and gluteal fold behind to the knee. The **leg** includes all of the lower extremity between the knee and the ankle. The **foot** includes all between the ankle-joint and the ends of the toes.

1. Palpate and mark with a dermatographic pencil the following landmarks: Anterior and posterior superior spinous processes of the ilium, great trochanter, tuberosity of ischium, lower borders of inner and outer condyles of femur, middle of patella, upper borders of inner and outer tuberosities of the tibia, tubercle of tibia, head of fibula, lower borders of inner and outer malleoli.

2. Take a steel tape-measure and, with the person to be examined lying upon the opposite side, mark out the ***Roser-Nélaton line.*** It is the line connecting the anterior superior spine of the ilium with the tuberosity of the ischium (see Figs. 51 and 97), and passes along the upper border of the greater trochanter, the latter being usually referred to, as will be done here, as the *trochanter*. In fractures of the neck of the femur, or in dislocations of the hip, this relation of the above three bony points is changed (see below), the trochanter then being above the line.

3. With the person to be examined lying upon his back, drop a line vertically downward from the anterior superior spine of the ilium. Mark a second oblique line from the same point to the upper border of the trochanter, and a third horizontal line from the trochanter to join the first-mentioned vertical line. These three lines form ***Bryant's triangle,*** which is also a standard measurement in hip injuries (see below).

4. Note the position of the gluteal fold; the lower border of the gluteus maximus lies a little above it. Also palpate the firm band (ilio-tibial) of fascia lata (tensor fasciæ femoris muscle) which extends from the ilium to the trochanter and is relaxed in fractures of the neck of the femur.

5. Draw a line with the steel measure (when the limbs are adducted) from the anterior superior spine through the middle of the patella to the lower border of the inner malleolus (see Fig. 134). Compare this with the same measurement of the opposite limb. There is at times a difference of one-fourth to one-half inch under normal conditions, the right

Fig. 132.—Method of palpating inguinal lymph nodes. The examining hand is placed flat upon the anterior aspect of the thigh, the finger-tips resting on Poupart's ligament, or rather the skin overlying it, and the nodes thus palpated by a rolling motion of the finger-tips.

Fig. 133.—Measurement of length of limb to be employed in cases of dislocation of the head of the femur or fracture of its neck. One end of the steel tape-measure is laid upon the anterior superior spine of the ilium, which has been previously outlined with ink or a blue pencil, while the other hand holds the tape-measure immediately below the inner malleolus. The tape passes through the middle of the patella. Both limbs should be placed flat upon the table at an equal distance from the median line, i. e., adducted.

being shorter than the left (see below). These measurements are of the greatest value in order to determine shortening due to injuries or diseases.

6. Palpate the powerful quadriceps extensor muscle on the front of the thigh, and observe how its aponeurosis passes around and over the patella and is continued below the latter as the strong ligamentum patellæ to the tubercle of the tibia. The ligament is best felt when the knee is slightly flexed.

7. Note the movements of the hip-joint—adduction and abduction (see Figs. 134 and 135), flexion (Fig. 137), extension, internal and external rotation.

8. Palpate the adductor muscles at the inside of the thigh and the hamstring (outer and inner) tendons at the back of the knee. Between the latter, close to the lower end of the femur, the popliteal space begins. The gracilis, semimembranosus and semitendinosus (the inner hamstring), and the biceps (outer hamstring) cause flexion of the knee-joint.

9. Mark the sides of Scarpa's triangle (Poupart's ligament, inner border of the sartorius and outer border of adductor longus); in it the pulsations of the femoral artery can be felt.

10. Palpate the lymphatic glands lying above and below Poupart's ligament; those above it drain the external genitalia and anus; those below it drain the lower extremities (see Figs. 51 and 59).

11. Palpate the condyles of the femur and the tuberosities of the tibia. Note the movements of the knee-joint—flexion (see Fig. 137), extension, and some external and internal rotation. Note the furrows or depressions on either side of the patella; they are obliterated in effusions into the knee-joint (Fig. 59).

12. Measure the length of the shaft of the femur from the upper border of the trochanter to the lower border of the outer condyle. Compare it with the opposite femur.

13. Measure the lengths of the tibiæ from the upper border of the inner tuberosity to the lower border of the inner malleolus (Fig. 134). Also measure the fibulæ from the upper border of the head to the lower border of the outer malleolus.

14. Mark on the surface the lines of the epiphyseal cartilages (according to Fig. 116) of the femur, tibia, and fibula.

15. Palpate the anterior border and internal surface of the tibia as far down as the outer malleolus; the remainder of the tibia is covered by muscles. Palpate the fibula; only the head, lower third of the shaft, and the external malleolus can be felt.

16. Palpate and note the actions of the extensor and peroneal mus-

cles, which cause a fullness on the outer upper aspect of the leg. The extensors (longus digitorum and proprius hallucis) extend the toes—*i. e.*, bend them upward—and flex the ankle (Fig. 137). The peroneal muscles (longus and brevis) raise the outer border of the foot. When paralyzed, as in infantile spinal paralysis, this outer border of the foot droops and cannot be raised (paralytic club-foot).

17. Palpate the large muscles of the calf (soleus and gastrocnemius) to their tendon (tendo Achillis) inserted into the calcaneus. Note their action: they flex the knee and extend the foot (Fig. 137).

18. Note the action of the tibialis anticus and posticus. They lie on the inner side of the tibia and raise the inner border of the foot.

19. The movements of the ankle-joint are flexion, extension, inversion, and eversion (Fig. 137). Flexion is produced by the tibialis anticus and the extensors chiefly. Extension is effected chiefly by the muscles of the calf—the tibialis posticus, peroneal muscles, and flexors. Inversion—that is, raising the inner border of the foot—is produced by the tibialis anticus and posticus. Eversion (raising the outer border of the foot) is produced by the peroneal muscles.

20. Palpate the posterior tibial artery behind the inner malleolus (Fig. 135).

21. Palpate the malleoli. The tip of the external is situated one-fourth of an inch lower and three-fourths of an inch further back than that of the internal malleolus.

22. Palpate the depressions in front of and behind the malleoli. In effusions into the ankle-joint these are obliterated.

23. On the foot palpate the tubercle of the scaphoid just below and in front of the internal malleolus.

24. Palpate the tuberosity of the calcaneus into which the tendo Achillis is inserted. Also palpate the joint between the internal cuneiform and first metatarsal bones on the inner side of the foot, and the joint between the cuboid and the metatarsal of the little toe. Note the action at the metatarso-phalangeal joint, which consists in flexion, extension, some abduction, and adduction—that is, from and to the middle line of the second toe.

25. Observe the action of the toes, flexion and extension. Mark out a line from the tubercle of the tibia to a point midway between the two malleoli on the anterior surface. This constitutes the axis of the leg (see Fig. 134), and, when prolonged from this latter point (midway between the two malleoli) in front, extends to the interspace between the two toes.

26. Measure the circumference of the thigh and of the calf of the leg

Fig. 134.—Lines of measurement of lower extremities and angle of abduction of the hip-joint. The left leg is seen in the position of maximum abduction. The line of measurement of the lower extremity usually taken from anterior superior spine of ilium (A), through middle of patella, to the lower border of the inner malleolus (B) is shown. In the leg, under normal conditions, the true axis of the leg and foot is a line drawn from C (middle of the patella) to a point D, midway between the two malleoli and terminating at E, which is the base of the interspace between the great and second toes. The length of the tibia can be measured from a point, F, the upper border of the inner tuberosity, to the lower border of the inner malleolus.

Fig. 135.—Angle of adduction of the hip-joint; tendon-sheaths around ankle-joint on front and inner side of foot and patellar bursæ. 1, Tendon-sheath of tibialis anticus. 2, Tendon-sheath of the extensor hallucis longus. 3, Common tendon-sheath of the extensor longus digitorum. 4, Tendon-sheath of the tibialis posticus, behind which lies a short tendon-sheath for the flexor longus digitorum and flexor longus hallucis. 5, Prepatellar bursa. 6, Bursa between the insertion of the ligamentum patellæ and tubercle of the tibia. 7, Angle of adduction of the hip-joint.


Fig. 136.—Surface markings on back of leg. 1, Sciatic nerve. 2, Internal popliteal nerve. 3, External popliteal nerve. 4, Popliteal artery. 5, Posterior tibial artery accompanied by the posterior tibial nerve. 6, Peroneal artery.

Fig. 137.—Movements of joints of lower extremity, showing the angles of maximum flexion of the hip-, knee-, and ankle-joints at 1, 2, and 3, respectively, and the angle of maximum extension of the ankle-joint at 4. 5, 6, and 7, Best points to measure circumference of thigh, knee, and calf.

**Surface Markings of Lower Extremity.**—1. The course of the **femoral artery** and vein corresponds to a line extending from a point midway between the anterior superior spine of the ilium and the symphysis pubis to the internal condyle (upper and back part). The artery lies on the anterior aspect of the leg in the upper third of this line (see Fig. 138), on the internal aspect (Hunter's canal) in a little more than its middle third, and more toward the posterior aspect in its lower third.

2. **Femoral vein.** Same line as for the femoral artery, lying to its inner side above and outer side below (Fig. 138).

3. **Anterior crural nerve** accompanies femoral artery and vein in their upper third (Fig. 138).

4. The **popliteal artery** corresponds to a line drawn along the middle of the back of the thigh from the junction of its lower and middle thirds (upper end of popliteal space) almost vertically downward to a point corresponding to the level of the tubercle of the tibia in front (Figs. 136 and 138). The popliteal vein lies to its outer side above, but opposite the knee-joint lies at a more posterior level, that is, more superficially.

5. The **posterior tibial artery** corresponds to a line drawn from the middle of the posterior aspect of the leg, at the level of the tubercle of the tibia, to a point midway between the internal malleolus and tendo Achillis (Fig. 136).

6. The **peroneal artery** lies at a deeper level than the posterior tibial. Its upper point on the surface is the same as that of the posterior tibial; that is, it is given off about three inches below the head of the fibula, and a line from this point to one between the external malleolus and tendo Achillis corresponds to its course (Fig. 136).

7. The **anterior tibial artery** corresponds to a line drawn from a point two inches below the tubercle of the tibia, on the anterior aspect of the leg, to a point midway between the two malleoli on the front of the ankle-joint. In its entire course it lies between the tibia and fibula until its lower third, where it lies in front of the tibia (Fig. 138).

8. The **external or short saphenous vein** corresponds to a line from the outer side of the tendo Achillis along the posterior aspect of the leg, to a point opposite the knee-joint (Fig. 58).

9. The **internal or long saphenous vein** (see Figs. 56 and 141) corresponds to a line from the internal malleolus, along the inner border of the leg and thigh, to Scarpa's triangle, close to Poupart's ligament. The saphenous opening is situated 1½ inches below and external to the pubic spine.

10. The **great sciatic nerve** corresponds to a line drawn from a

point midway between the tuberosity of the ischium and great trochanter and continued downward along the back of the thigh to the center of the popliteal space, that is, opposite the knee-joint (Fig. 136).

11. **External popliteal nerve, or peroneal nerve,** extends from the above point of division of the great sciatic behind the head of the fibula, and runs parallel to the peroneal artery as given above (Fig. 136).

12. The **anterior and posterior tibial nerves** accompany the arteries of the same name (Figs. 136 and 138).

## Buttock or Hip Region.

The boundaries of this region, also called the *gluteal region*, are the crest of the ilium (along its entire length) above, the gluteal fold below. This fold is a little above the lower border of the gluteus maximus, and is formed by a thickening of the fascia lata at this point. Under normal conditions the hip region is rounded and full and the gluteal fold well marked. In disease of the hip-joint (tuberculosis) the fullness disappears, owing to atrophy of the muscles, and the gluteal fold is obliterated. In general emaciation the large amount of fat beneath the skin of this region (see Fig. 102) is absorbed and the fullness of the buttock is replaced by a concavity or hollow.

The skin of this region is quite coarse and thick. It is a frequent seat of furuncles, which resemble those upon the back of the neck in hardness, owing to the dense infiltration of the tissues. The subcutaneous fat is very abundant (see Fig. 102), so that even in moderately nourished individuals there is a considerable space containing fat between the gluteus maximus and the skin.

The fascia lata separates the muscles of the region from the skin and fat. It is a powerful structure and gives a strong point of attachment for the muscles of the thigh. It begins at the crest of the ilium, and from this point to the outer tuberosity of the tibia forms an especially strong band of connective tissue—the iliotibial. It is continuous around the entire thigh, so that pus beneath it can spread rapidly in all directions. It also sends in prolongations between the muscles of the hip and thigh regions, separating them from each other, as will be referred to later.

In fractures of the neck of the femur (see Fig. 145) one of the earliest and most characteristic signs is the relaxation of the tense fascia lata, extending from the crest of the ilium to the trochanter.

The muscles of the hip or buttock act chiefly as abductors and external rotators of the lower extremity. In the early stages of hip-joint disease the reflex spasm of these muscles limits the motion at the hip, and they cause abduction and outward rotation (flexion being produced

Fig. 138.—Surface markings of blood-vessels and nerves on anterior surface of lower extremity. 1, Surface marking of external iliac artery and vein. 2, Surface marking of femoral artery. 2', Projection of popliteal artery on anterior surface of thigh. 3, Anterior crural nerve. 4, Femoral vein. 4', Projection of popliteal vein on anterior surface of thigh. 5, Anterior tibial artery surface markings. 6, Surface marking of anterior tibial nerve. 7 and 8, Show the relation (on the posterior aspect of the femur) of the popliteal artery (7) and vein (8) to a frequent seat of fracture (9) above the condyles of the femur, showing how the lower fragment can be pulled down by the gastrocnemius muscle and compress these vessels. P, Psoas muscle, or rather iliopsoas muscle, along which cold abscesses travel from the dorsolumbal junction of the spine, within the sheath of this muscle, and appear externally at the saphenous opening, close to the attachment of the muscle, at A, lesser trochanter.

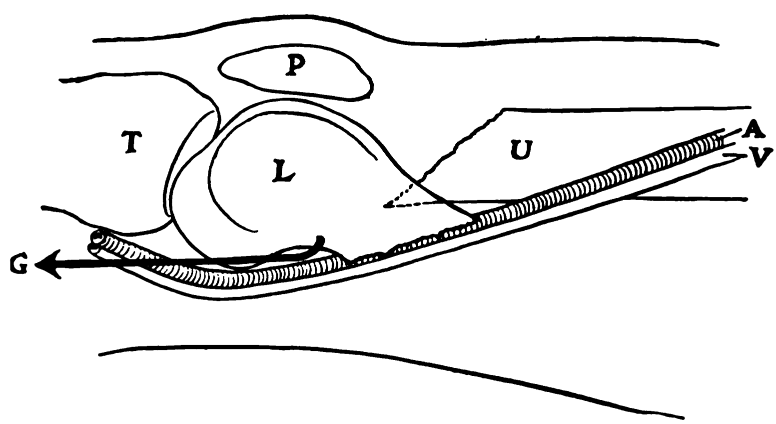


Fig. 139.—Supracondyloid fracture of femur showing how gastrocnemius muscle, whose action is represented by the black arrow, terminating at the letter G, causes the lower fragment to be pulled downward and backward, impinging upon the popliteal artery and vein, and resulting in gangrene of the leg in some instances.

by the muscles on the anterior aspect). The abduction causes an apparent lengthening of the entire limb, due to the tilting of the pelvis.

These muscles are arranged in three layers (Fig. 102), from without inward: (1) gluteus maximus; (2) gluteus medius, pyriformis, obturator internus, gemelli, and quadratus femoris; and (3) the obturator externus and gluteus minimus. Beneath the first layer (gluteus maximus) lies the **sciatic nerve,** which leaves the pelvis through the great sacrosciatic foramen, below the pyriformis. It is most accessible to pressure at a point midway between the trochanter and tuberosity of the ischium, and this is usually the painful spot in sciatica, the pain then being referred along the back of the thigh to the knee (course of the nerve). The nerve can be best exposed here by dividing the fibers of the gluteus maximus. This nerve may divide either inside of the pelvis, just outside of the latter, or in the middle third of the thigh, into its two principal branches—the peroneal (external popliteal) and tibial (internal popliteal).

The sciatic nerve is accompanied by an artery which is a branch of the internal iliac, and veins which are branches of the same named vein. This sciatic artery may become an important factor in the establishment of collateral circulation in aneurisms of the femoral or the external iliac artery. In obstruction of the corresponding veins the free anastomoses of the veins of this entire region with the veins of the pelvis (branches of the internal iliac) aid in the return of the blood to the vena cava. The superior gluteal artery and nerve emerge from the pelvis above the pyriformis and the inferior gluteal artery and nerve; below it, the latter and the internal pudic artery and nerve accompany the sciatic nerve. The internal pudic re-enters the pelvis to be distributed to the perineum (see Fig. 97). The gluteal vessels and nerves supply the muscles of this region. The arteries are of large size and may be wounded in gunshot or stab wounds of the hip and give rise to severe hemorrhage. They may also be the seat of aneurisms.

In **non-impacted fractures of the neck of the femur** the above muscles (see Fig. 145) pull the neck and shaft upward and cause the leg to roll outward, partly on account of its weight, but mainly owing to their function as external rotators. The trochanter thus comes to lie above the Roser-Nélaton line which was referred to above, in the examination during life. In either congenital or acquired backward dislocations, in fractures of the neck of the femur, or in disease of the head and neck of the bone, with destruction of the same, the trochanter, the upper border of which normally is in this line, lies one to two inches

above it. Between the trochanter and the gluteus maximus muscle lies a large bursa—the trochanteric (see Fig. 60).

Inflammation of this bursa may cause swelling, sensitiveness, limping, and some limitation in motion, at times greatly resembling hip-joint disease. It lacks, however, the reflex muscular spasm above spoken of. The hip-joint can be best reached, for purposes of drainage or resection, through an incision in this region (Langenbeck's) curving around the posterior edge of the greater trochanter.

## Anterior Thigh Region.

The upper portion of the thigh is often described separately as the subinguinal region, or groin, the boundaries of which correspond to those of Scarpa's triangle. The skin of this subinguinal region is very fine and Scarpa's triangle. The skin of this subinguinal region is very fine and elastic, so that it will permit of great distention in cases of psoas abscess, femoral hernia, etc. The superficial fascia may be divided into two layers—a more superficial layer, or fatty layer, and a deeper membranous one. The latter is attached to Poupart's ligament and to the pubic arch. Below Scarpa's triangle it blends with the superficial layer. These attachments of the deeper layer prevent fluid, such as extravasated urine, pus, etc., from passing down the thigh from the abdomen or perineum. Between the superficial and deeper layers lie the inguinal glands (Fig. 59), the internal saphenous vein (see Fig. 56), and some small superficial branches of the femoral artery and vein (superficial epigastric, circumflex iliac, and external pudic). These latter vessels may, by their anastomoses with the branches of the lumbar, intercostal, or internal mammary arteries and veins, play an important rôle (see Fig. 57) in establishing a collateral circulation. The lymphatics are arranged in two sets; the upper lies along Poupart's ligament. This upper set drains the anal canal, perineum, lower portion of vagina, male and female external genitalia, and skin of lower half of abdominal wall and gluteal region (see Fig. 59). They frequently become enlarged on one or both sides in venereal disease (soft chancre, gonorrhea, or syphilis) or in carcinoma of the penis, anus, vagina, etc. Their suppuration causes them to become firmly adherent to each other and to the underlying femoral vessels, especially in lean people. The close proximity of these large vessels must be borne in mind in their removal.

The other or lower set of lymph glands (crural) lies parallel to the femoral vessels over Scarpa's triangle. They receive lymph from the entire lower extremity. When an abscess or any enlargement of these glands is found, the cause must be looked for along the entire limb to the

Fig. 140.—Varicose ulcer of leg.

involved in infections occurring in the area drained by the latter. Both of these sets of glands empty their lymph into the deep iliac glands lying beneath the iliac fascia. After suppuration and incision of the superficial glands, a continuation of fever and septic symptoms should lead us to suspect an extension to the deeper iliac glands.

In malignant tumors of the testis the involvement of the inguinal and iliac glands may be greater than the primary growth.

The **internal saphenous vein** (see Figs. 56 and 141) penetrates the fascia lata 3 to 4 cm. (1¼ to 1½ inches) below Poupart's ligament, passing across the lower edge of the saphenous opening to empty into the femoral vein. This vein is frequently ligated in this region for the cure of varicosities of its own and tributary trunks (see Fig. 141). It can be found along the inner aspect of the thigh between the superficial fat and the fascia lata (see Fig. 102). It is one of the longest veins in the body, beginning on the dorsum of the foot (Fig. 56) and returning the blood from the skin of the foot and entire inner side of the leg and thigh. It receives a great many branches, and communicates freely with the external saphenous vein (see Fig. 141). Its varicosities may become the seat of a painful thrombophlebitis, or may cause ulceration, eczema, etc., through interference with the cutaneous blood-supply (varicose ulcers). The frequency of recurrence after ligation of the main trunk (Trendelenburg) or of its branches (Schede) is due to the many anastomoses and to the fact, as shown in figure 141, of the occasional occurrence of two parallel trunks of equal size.

Beneath the skin, fat, and superficial fascia of the groin, or subinguinal region, is the **fascia lata,** which is continuous with that of the hip and remainder of the thigh. Close to Poupart's ligament it consists of two layers (see Fig. 102); the deeper covers the pectineus muscle and unites about 1½ inches below the ligament (Poupart's) with the more superficial (which is a continuation of the iliac fascia) to form a sheath for the femoral vessels. To the inner side of the femoral vein an opening is left through which a femoral hernia escapes (see page 248). The fascia lata has an opening (saphenous) here, covered by loose connective tissue, across the lower edge of which the internal saphenous vein turns to empty into the femoral. Through this opening a femoral hernia escapes toward the surface.

Pus from disease (tuberculosis) of the lower dorsal and lumbar vertebræ follows the sheath of the psoas muscle to the lesser trochanter, and then escapes to the surface through the saphenous opening, so that a fluctuating, painless swelling at this point of the thigh should always be carefully examined in order to differentiate it from a

femoral hernia. Beneath the fascia lata lie the **femoral artery and vein,** and the **anterior crural nerve.** A convenient way to remember the relations is to think of the word "navel"—the nerve (anterior crural) lying to the outer side; the artery next; the vein still more internal; then an empty space (see Fig. 76), the crural or femoral canal; and, most internally, Gimbernat's ligament. The artery, in addition to a number of smaller superficial branches referred to above, gives off the **profunda femoris** one inch below Poupart's ligament.

This latter artery, through its anastomoses with the gluteal and sciatic arteries, establishes a collateral circulation after ligation of the femoral. At times the femoral is poorly developed and the main blood-supply of the lower limb is derived through the profunda. The femoral artery is quite accessible to pressure or ligation here in Scarpa's triangle. The boundaries of the latter can be readily palpated except in stout persons, being the sartorius on the outer, the adductor longus upon the inner side, and Poupart's ligament above.

Beneath the vessels here, lie the muscles in front of the hip-joint and the head and neck of the femur and trochanters. An inspection of figure 102 will aid in understanding these relations. The vessels lie directly upon the iliopsoas and pectineus muscles, which act as flexors of the hip. Beneath the iliopsoas lies a large bursa (the iliac), separating it from the horizontal ramus of the pubes. This may become inflamed and simulate a disease of the hip-joint. In about 10 per cent. of all persons it communicates with the joint. Pus from the hip-joint may escape through the anterior part of the capsule between the deep muscles here toward the surface. The head of the femur cannot be felt except in very emaciated individuals.

Just beneath the pectineus muscle is the obturator opening, through which the obturator nerve and vessels emerge from the pelvis. Through this gap in the membrane closing the obturator foramen a hernia (see Fig. 79) may form and be very difficult to diagnose. The distribution of branches to the head of the bone by the obturator nerve explains the frequent early reference of pain in inflammation of the hip-joint to the knee, which the nerve also supplies.

On the inner side of the thigh at this level lie the adductor muscles; on the outer lies the sartorius. The rectus femoris also lies in front of the neck of the femur.

## Hip-joint.

The relations and construction of this joint can be understood from a horizontal and vertical section of the same (see Figs. 80, 102, and 112).

Fig. 141.—Varicosities of internal saphenous vein. In this case there were two internal sapheni running parallel to each other, indicated by the figures 1 on both limbs, explaining a frequent cause of failure in the Trendelenburg operation for varicose veins.

The acetabulum forms a hemisphere which is deepened by the cotyloid ligament attached to its edges. The head of the femur exceeds a hemisphere and is not in contact with the acetabulum at all points. The center of the acetabulum is filled by fat, and at this point the ligamentum teres, by which the head is held, is attached. It is quite thin here, and easily perforated, especially in children, pus escaping through the opening into the pelvis. With the exception of this center, the acetabulum is covered by cartilage. The head is also covered by cartilage except at the point of attachment of the ligamentum teres (see Fig. 142).

The *capsule* is weakest at its posterior lower portion, and is most easily perforated here. The capsule is attached in front to the anterior intertrochanteric line, above to the inner aspect of the root of the great trochanter, below to the lower part of the neck close to the lesser trochanter, and behind to the line of junction of the outer and middle thirds of the neck. Thus, only a part of the posterior surface of the neck is inclosed within the capsule. The synovial membrane (see Fig. 142) is smaller than the capsule, and posteriorly, where the attachment of the latter is weak, the membrane may be seen extending beyond the capsule. The upper epiphyseal cartilage of the head of the femur (see Fig. 116) lies within the joint cavity. Tuberculosis of this end of the bone often occurs here, owing to the bacilli being arrested in the imperfectly formed capillaries. For this reason the disease invades the joint at an early stage.

The **movements of the hip-joint** are (see Figs. 134 and 135):

Abduction—carrying the limb away from the median line.
Adduction—carrying the limb toward the median line.
External rotation—turning the limb outward.
Internal rotation—turning the limb inward.
Flexion—of the thigh upon the abdomen (Fig. 137).
Extension—of the thigh upon the pelvis, *i. e.*, pushing it back.

These movements are executed by the muscles described in the hip and groin, with the aid of the flexors and extensors of the knee (see below).

**Dislocation of the hip** may be congenital or acquired. In general it is less frequent than in the shoulder, owing to the greater depth of the acetabulum, and the fact that the capsule is strengthened by powerful ligaments, especially in front (iliofemoral and iliopubic). These latter ligaments, as well as the ligamentum teres (Fig. 142), which binds the head to the bottom of the acetabulum, require an enormous force to break them, and thus greatly protect the joint.

The weakest portion of the capsule of the shoulder is below, while that of the hip is behind. Hence downward and forward dislocations are more frequent (76 per cent.) in the former, and backward and upward in the latter (hip-joint).

An **acquired dislocation** (see Fig. 144) generally results from an exaggeration of a normal movement of the joint, *i. e.*, by indirect force. In the backward variety an abnormal amount of flexion and abduction causes the head to be forced against the posterior weaker portion of the capsule, which gives way after the ligamentum teres breaks. In the *iliac form* the head rests upon the ilium, above and behind the acetabulum. In the *ischiadic form* (rarer) the head rests upon the ischium. After such a backward displacement the limb is found to be shorter, the trochanter lies above the Roser-Nélaton line, the limb is adducted, flexed, and rotated inward.

As stated above, the forward dislocation is rarer. It is produced by excessive outward rotation and abduction, the capsule tearing in its anterior portion. The head is found either above the pubis or below it (see Fig. 144). The limb is held in a position of flexion, abduction, and outward rotation, the opposite of a posterior dislocation.

Acquired dislocation of the hip may occur without any appreciable trauma, as the result of rheumatism, scarlatina, or influenza (case reported by author). Such displacements are usually posterior and due to the fluid which weakens and distends the capsule, pushing or pulling the head out of the acetabulum.

**Congenital dislocation** is most frequently of the posterior variety (see Fig. 143). It is oftener unilateral, and occurs more frequently in females (88 per cent.). It is due to the head being forced out of the acetabulum at an early period of intrauterine life, the result of the closer application of the uterine wall to the hip, owing to a decreased amount of liquor amnii (Hoffa). The acetabulum becomes flatter (see Fig. 143), and the capsule is usually stretched to inclose the head in its new resting-place. The muscles around the hip are shrunken and atrophied.

## Fractures of the Upper End of the Femur.

In the normal adult the neck of the femur forms with the shaft an average angle of 127 degrees (see Fig. 142). In elderly people this is not changed, as was thought formerly. At this latter age the cortex of the neck becomes thinner and the meshes of cancellous tissue enlarged (osteoporosis). Hence the bone becomes more brittle at the neck and


Fig. 142.—Vertical section of hip-joint, seen from behind. The angle which the head under normal conditions forms with the shaft (127 degrees) is marked out. I, Rim of acetabulum in vertical section. C, Cavity of joint (exaggerated), showing the extent of the joint capsule. L, Ligamentum teres.

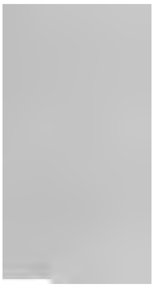

**Fig. 143.**—*X*-ray picture of congenital (right-sided) dislocation of the femur at the hip-joint.

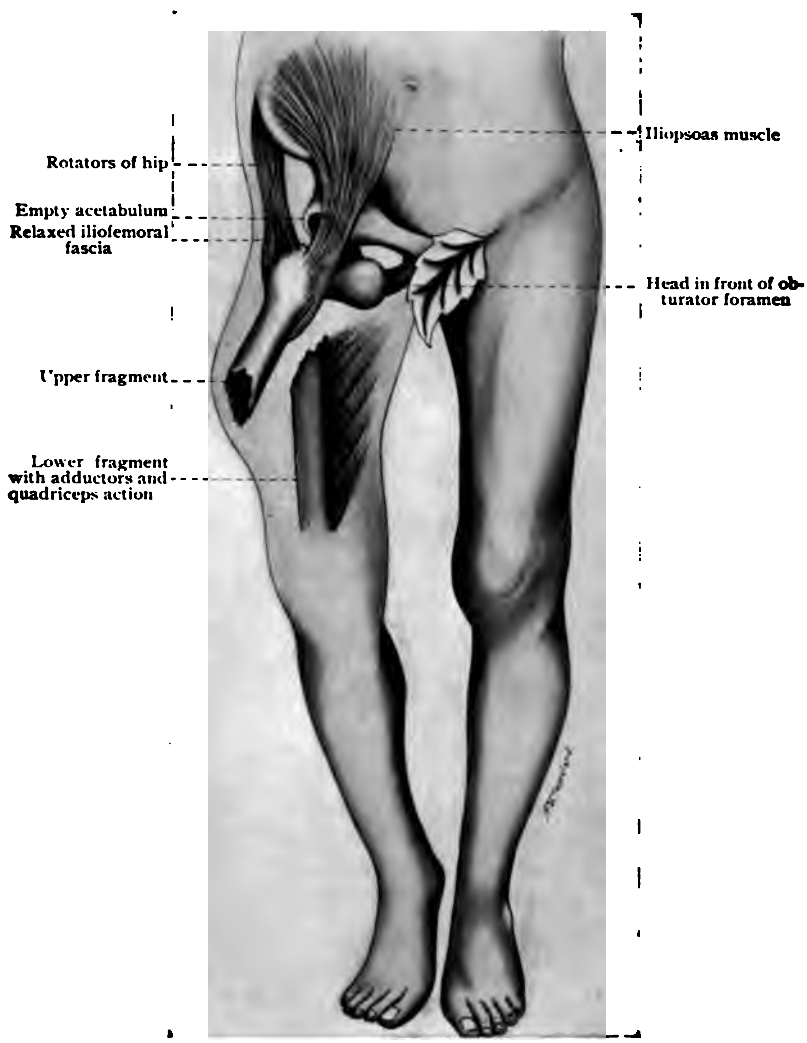


Fig. 144.—Forward dislocation of hip and fracture at middle of shaft of femur showing action of muscles of pelvis and upper portion of hip (iliopsoas, obturators, etc.), in causing the upper fragment to be pulled upward and outward, and the lower fragment to be pulled upward and inward by the adductor muscles. Made from $x$-ray picture.

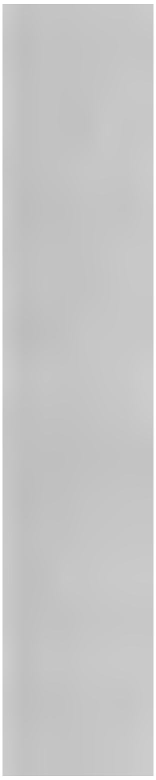


Fig. 145.—Fracture of neck of femur (from x-ray picture) showing action of rotators of hip and iliopsoas muscle in causing shortening and rotation outward of lower extremity (eversion of foot, etc.).

is most likely to break here in elderly people. A slight fall upon the trochanter will cause either an impacted or a non-impacted fracture (see Fig. 145). The limb is shorter, the trochanter lies above the Roser-Nélaton line, and it is rotated outward. At the same time the tense fascia lata, extending from the crest of the ilium to the trochanter, is relaxed.

Such a fracture of the neck of the femur may occur as the result of violence in young people. A separation of the head from the neck may occur in children at the upper epiphyseal cartilage, and also a separation of the trochanteric epiphysis (see Fig. 116), but are rare.

## The Thigh.

The gluteal (buttock) and subinguinal (groin) regions and the hip-joint have been described above. The skin is firmer and not very elastic. There is usually quite an amount of subcutaneous fat, and in it lie the superficial veins, the largest of which is the internal saphenous (see Fig. 141). This vein, after winding around the internal condyle, lies in the fat close to the fascia lata behind the edge of the sartorius and accompanied by the saphenous nerve. Its course and tendency to varicosities have been described on page 441. The cutaneous nerves also lie in this fat; they are the internal, middle, and external cutaneous. The fascia lata forms a perfect sheath for all of the muscles of the thigh, so that, if torn, the muscular substance prolapses through the gap. The fascia is strongest on the outer side, owing to the iliotibial band (see page 432). From the fascia lata two strong septa pass inward (see Fig. 102), called the external and internal intermuscular septa respectively. These septa form three muscular compartments:

The Anterior—containing the Quadriceps and Sartorius.
The Inner—containing the Gracilis, Pectineus and the three Adductors.
The Posterior—containing the Biceps, Semitendinosus, and Semimembranosus.

Just above the knee the fascia lata, after covering the quadriceps and patella, is attached to the capsule of the knee-joint. In every fracture of the patella there is more or less of a tear of this fascia and of the aponeurosis of the quadriceps, causing the fragments to be pulled apart. At the same time this fascio-aponeurotic expansion is so strong that, in spite of considerable separation of the fragments of the patella, with a fibrous union, the patient still has considerable power of extending the knee. The relation of this aponeurosis to the patella will be referred to later.

Upon the anterior aspect lie the **femoral artery and vein.** From

Poupart's ligament to the apex of Scarpa's triangle they lie quite superficial on the inner side of the sartorius. In the middle third of the thigh they lie beneath this latter muscle, and in the lower third in Hunter's canal. The artery thus lies on the anterior aspect of the thigh above, the inner aspect in the middle, and on the posterior aspect in the lower portion of its course (Fig. 138). The vein can be easily separated from the artery, it lies to its inner side above, then crosses behind it and lies to its outer side below.

The proximity of all these vessels to the inner side of the shaft of the femur renders it easier to open it for osteomyelitis, etc., upon the outer side.

Upon the posterior aspect of the thigh the principal structure is the **sciatic nerve** (see Fig. 102). It divides into the peroneal and tibial nerves (Fig. 136). This takes place most frequently at the upper end of the popliteal space, but may occur as high up as its point of exit from the pelvis, or even inside of the latter. The sciatic gives off a few muscular branches to the biceps, semimembranosus, and semitendinosus. The nerve is quite well surrounded by fat and connective tissue (see Fig. 102) in its entire course. In sciatica its course can be well marked out by the tenderness along the middle of the back of the thigh.

### Fractures of the Shaft of the Femur.

These occur usually at one of three places:

1. Just below the trochanter (subtrochanteric).
2. At the middle of the shaft.
3. Just above the condyles.

They are generally oblique; the displacement of fragments is so great, owing to the powerful muscles on all sides, that it is necessary to apply weights to the limb in order to counteract them. In subtrochanteric fractures the flexor muscles of the hip (pectineus, ileopsoas) tend to pull the upper fragment upward and forward on account of their attachment to the lesser trochanter. In fractures of the shaft (see Fig. 144) the glutei cause the upper fragment to be abducted and the quadriceps and adductors pull the lower fragment upward and inward. Unless this is borne in mind in the treatment, and the leg abducted, there will be both shortening, due to the overriding of fragments, and angular deformity (Fig. 144) (outward bowing).

In supracondyloid fractures the two heads of the gastrocnemius, being attached to the femur just above the condyles, pull the lower frag-

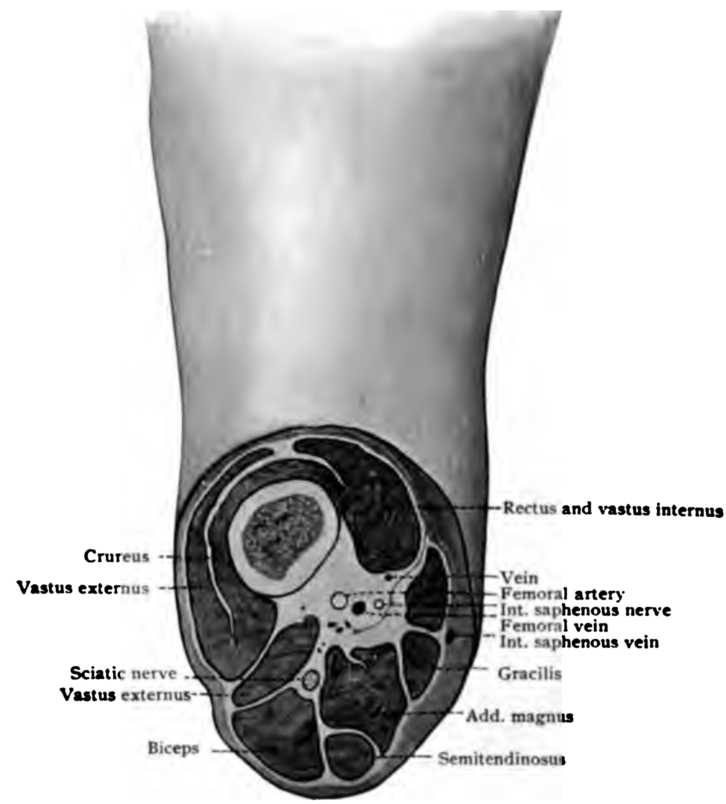


Fig. 146.—Section through right thigh at level of Hunter's canal. Femur is seen just above and to outer side of femoral vessels.

ment downward and backward. Unless the proximity (see Figs. 138 and 139) of the popliteal vessels and sciatic nerve to the bone is remembered, gangrene or paralysis of the leg may result from pressure of the lower fragment upon the structures. This can be avoided by flexing the knee (use of double inclined plane splint) in order to relax the gastrocnemius muscle.

The femur is frequently divided below the condyles (subtrochanteric osteotomy) to relieve deformities following injuries or diseases of the hip-joint or neck of femur. The lower end of the shaft is also at times operated upon (Macewen's osteotomy) for relief of a deformity known as genu valgum.

## The Knee Region and Knee-joint.

The skin over the front of the knee is thin and elastic, so that it permits of great swelling in the knee-joint. To both sides and above the patella there are depressions which disappear when fluid is present in the joint (Fig. 59). Normally the patella can be moved readily up and down, as well as from side to side. When fluid is present in the joint, the patella rides upon it, giving rise to the phenomenon of the "dancing patella," or ballottement. The patella under these conditions, when pressed upon, rebounds.

Beneath the skin lies the continuation of the fascia lata of the thigh, which is so closely adherent to the aponeurosis of the quadriceps and to the capsule of the joint as to form one membrane. In **fractures of the patella** this fascio-aponeurotic membrane is frequently torn and pulls the fragments apart. It covers the anterior surface of the patella, being densely adherent to the periosteum, and is apt to prolapse into the gap between the fragments of a fracture, constituting one of the most frequent causes of non-union. Between the skin and fascia covering the patella lies the bursa ordinarily spoken of as the *prepatellar* (see Fig. 148). In reality it should be called the subcutaneous, to distinguish it from two others. One of the latter lies between the fascia and aponeurosis (subfascial); the other between the aponeurosis and the bone (subaponeurotic). These two latter bursæ seldom inflame. The subcutaneous one becomes either acutely inflamed as the result of a fall upon the knee, and may suppurate, or it becomes filled with mucus and rice-bodies (fibrin) as the result of long-continued irritation (housemaid's knee).

Upon the inner side the knee-joint is covered by the sartorius, semitendinosus, and gracilis, which spread out before being attached to the tibia. Upon the outer side lies the biceps.

Over the back of the joint is the **popliteal region,** which is bounded

above and laterally by the semimembranosus, semitendinosus, and gracilis on the inner, and the biceps on the outer side; below, it is bounded by the two heads of the gastrocnemius. In the rhomboidal space which is thus formed lie the popliteal vessels and chief branches of the sciatic nerve (see Figs. 138 and 146). The skin is very thin, and one can palpate in most individuals the tibial nerve and popliteal artery. Just beneath the skin lies the external or short saphenous vein, which penetrates the fascia to empty into the popliteal. It is shorter than the internal saphenous and less apt to be the seat of varicose veins.

The fascia (popliteal) is a continuation of the fascia lata. The entire **popliteal space or fossa** is filled with fat, which protects the vessels and nerves in it from the direct effect of pressure. The popliteal artery is closely adherent to the popliteal vein throughout its course. The vein lies more superficially and to the outer side of the artery. The artery lies directly upon the femur and capsule of the joint in the upper part of the back of the knee and upon the popliteus muscle below. The close relation of the vein and artery to the lower end of the femur renders it liable to injury in supracondyloid fracture of the femur (see Fig. 138). Their proximity to the posterior portion of the capsule makes it necessary to use great caution not to injure them in resection of the knee.

The **sciatic nerve** usually divides (see Fig. 136) at the middle of the thigh, or higher, into its two principal branches—the peroneal (external popliteal) and tibial (internal popliteal). The latter is the more superficial (see Fig. 146) and lies to the outer side of the artery, crossing it and the vein a little lower down, to divide into the anterior and posterior tibial. The peroneal follows the head of the biceps to the head of the fibula, winding around the latter to the outer side of the leg. It is apt to be wounded in this exposed position in the faulty application of a constrictor, or in fracture just below the head of the fibula. At the back of the knee is one of the best places to elicit pain on pressure in neuritis involving the sciatic or its main branches (Fig. 136).

Aneurisms of the popliteal artery occur as the result of long-continued pressure here. In the fat of the popliteal space lie also a few lymph-glands (see Fig. 148) which drain the back of the leg and communicate with those of the groin.

The arterial and venous supply around the knee-joint is chiefly derived from the popliteal and tibial vessels. They form a superficial and deep network, providing free anastomosis.

Beneath the semimembranosus tendon lies a bursa which may inflame and which at times communicates with the joint (Fig. 60).

The **knee-joint** is formed by the patella, condyles of the femur, and

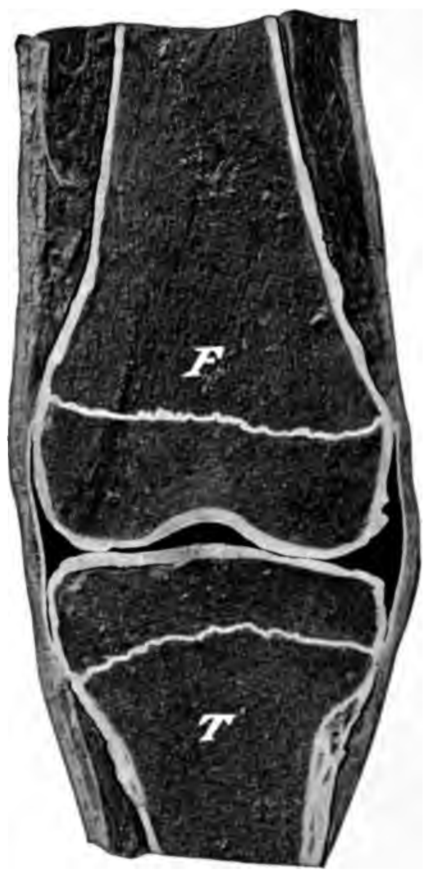


Fig. 147.—Coronal section of knee-joint. F, Femur. The figure is placed in the diaphysis of the bone; below it is seen the epiphyseal cartilage and the epiphysis. The relations of the epiphysis to the joint can also be observed (see text). T, Tibia. Placed in the diaphysis of the bone. Above it is the epiphyseal cartilage and upper epiphysis of the tibia.

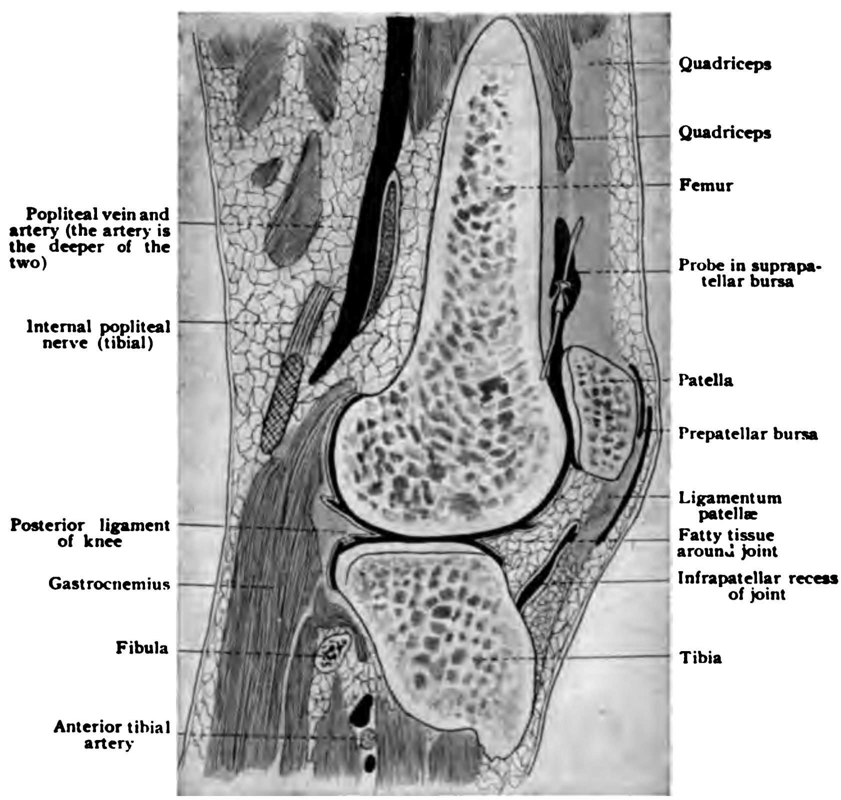


Fig. 148.—Sagittal section of knee-joint showing extent of synovial membrane (Bardeleben).

the tuberosities of the tibia, the upper end of the fibula not entering into the formation of the joint (see Fig. 147). The joint can be flexed beyond a right angle (see Fig. 137) and can be extended so that the thigh and leg are in the same plane. There is also a slight amount of inward and outward rotation possible. In walking the femur rotates upon the tibia in passing from extension to flexion, and vice versa, each condyle gliding or rolling in a cup formed by the semilunar cartilages, upon the tibia.

The crucial ligaments prevent any antero-posterior motion. Under normal conditions there is scarcely any lateral movement possible. In injuries to the knee involving the crucial ligaments abnormal forward and backward movement of the tibia upon the femur can be elicited. In a tear of the lateral ligaments the joint acquires an abnormal amount of side-to-side movement, and this may give rise to a genu valgum or varum traumaticum. The circumference of the knee-joint can be best measured over the middle of the patella (Fig. 137).

The **capsule** extends from 2 to 8 cm. (¾ to 3¼ inches) above the patella—laterally it is attached just above (½ inch) the articular surfaces of the condyles; below, just to the lower border of the articular surfaces of the tuberosities (Fig. 148); and behind, on the femur just above the condyles. In the majority of people it extends 8 cm. (3¼ inches) above the patella, so as to include the suprapatellar bursa (bursa subcruralis) (Fig. 148).

The **epiphyseal cartilages** of both the femur and tibia are not in direct relation to the joint (see Fig. 147). For this reason tuberculous foci can occur in the bone without involving the joint, and perforate externally, forming para-articular abscesses. The epiphyseal line of the femur is farther from the joint (see Fig. 147) than that of the tibia; hence one can resect a larger portion of the epiphysis of the femur without destroying the cartilage. In general, it may be said of every long bone of the body that it ceases to grow when the epiphyseal cartilage is destroyed by disease (tuberculosis, osteomyelitis), or occasionally by injury (epiphyseal separation), or, thirdly, through paralysis or injury of its trophic nerves (anterior poliomyelitis).

The capsule of the knee-joint is greatly strengthened by extra-articular ligaments on all sides (external and internal, lateral, anterior or ligamentum patella, and posterior of Winslow).

The bones are held still more perfectly in position by a series of intra-articular ligaments—the crucial ligaments, semilunar cartilages, etc. These prevent the slipping of one bone upon the other, excessive flexion, extension, and rotary movements.

The knee-joint is more accessible from the front than from behind, owing to the presence in the popliteal space of large vessels and nerves. The synovial membrane is the largest in the body, and follows the capsule closely. In all forms of exudate into the joint the swelling is at once seen in front (see Fig. 59), pushing the patella away from its resting-place upon the condyles (mostly the external). The joint can be best drained by an incision on either side of the patella.

Tuberculosis begins somewhat more frequently in the tibia and the femur (osseous form) than in the synovial membrane (synovial form). Various other forms of acute and chronic synovitis occur in the knee. The great tendency in all of these, upon the part of the patient, is to hold the knee flexed, in which position the inflamed surfaces are furthest apart. This deformity may become permanent.

Under normal conditions the internal condyle descends lower than the external, and in standing the weight of the body rests upon it, so that an angle of 172 degrees is formed, with closed side inward. The exaggeration of this occurs in **genu valgum**, or knock-knee, while a diminution of this angle, or its opening inward, is called **genu varum**, or bow-leg. These deformities occur most often in childhood, when the standing posture is first assumed. The deformity is due to a bending of the lower end of the femur in an inward or outward direction respectively.

**Fractures of the patella** occur most frequently through indirect violence. A sudden muscular contraction of the quadriceps (see Fig. 150) causes a fracture by practically pulling the bone apart, the lower end of the patella being firmly fixed by the ligamentum patellæ. At the same time the aponeurosis of the muscle and the overlying fascia are torn extensively.

In addition to tears of the extra-articular ligaments, the semilunar cartilages on one or both sides may be torn off, interfering with movements of the joint. Portions of the articular cartilages may be separated, forming floating bodies which in certain positions get between the articular surfaces and cause locking of the same.

## The Leg.

The upper boundary of the leg is a line drawn immediately below the tuberosities of the tibia, the lower boundary is formed by the malleoli. Upon the anterior aspect is the prominent anterior border and internal surface of the tibia, which lie just beneath the skin, so that the tibia can be felt along its entire length from the tuberosities to the malleoli. Osteomyelitis (acute suppurative) occurs quite frequently in the tibia and can be well located on account of the exposed position of the bone.

Fig. 149.—Tabetic knee-joint. The illustration shows the enormous enlargement of the lower end of the femur as a result of trophic disturbances and the ability to produce abnormal abduction in the knee-joint.

Fig. 150.—Fracture of patella (made from $x$-ray), arrow showing action of quadriceps extensor in pulling upper fragments upward, demonstrating how fracture by indirect violence (muscular action) can occur.

Owing to this superficial position the periosteum is frequently the seat of a traumatic inflammation, giving rise at times to great tenderness and thickening of the same. In syphilis one of the most frequent seats of the periosteal inflammation is in the vertex of the skull, the clavicle, the radius, and the internal surface of the tibia. In the latter place, during the acute stage of syphilitic periostitis, the bone is greatly thickened and extremely sensitive to touch. Even years after such an inflammation has passed away evidences of it can be found in a thickened condition of this surface of the tibia.

The skin of the **anterior aspect of the leg** has many hairs, especially in the male. The skin is more closely adherent to the underlying fascia than in the thigh, so that inflammation of the subcutaneous cellular tissue does not spread as rapidly, as a rule, as in the thigh. On the outer side lie the peroneal muscles (peroneus longus and brevis) (see Fig. 151), and internal to these the tibialis anticus and the extensors of the toes. The fascia is closely adherent to the muscles in the upper third, passing from the tibia to the fibula and inclosing all of the muscles of the anterior half of the leg and the deeper blood-vessels and nerves in two compartments (see Fig. 151). The internal compartment contains the tibialis anticus and the extensors of the toes, the anterior tibial artery, and the anterior tibial (deep peroneal) nerve. The external compartment is smaller, and contains the peroneus longus and brevis muscles and the musculocutaneous (superficial peroneal) nerve. Along this surface between the fascia and the skin run many branches of the saphenous (internal and external) veins. They frequently become thrombosed, giving rise to thickenings and even calcareous masses along their course. Owing to the resulting poor nutrition of the skin, varicose ulcers are especially prone to form over the exposed anterior surface of the tibia and around the external or internal malleolus.

The **anterior tibial artery** runs along the front of the interosseous membrane to the lower third of the leg, where it becomes quite superficial, lying upon the tibia (Fig. 138). It is accompanied by the corresponding deep veins. The latter may play quite a rôle after ligation of the internal saphenous, the theory being that after ligation of the superficial veins, the deep veins should carry back the blood of the limb; but often these are diseased or thrombosed, so that varicose veins recur on the surface.

The deep lymphatics of this region accompany the artery and empty into the popliteal glands (Fig. 60). The anterior tibial artery is accompanied by the deep peroneal or anterior tibial nerve (Fig. 138). This nerve supplies the tibialis anticus and the extensors of the toes, as

well as the peroneus tertius. It is frequently involved in infantile spinal paralysis (anterior poliomyelitis) as well as the musculocutaneous or superficial peroneal nerve. The effects of such paralysis will be referred to on page 499.

The skin of the **posterior aspect of the leg** is more elastic and there is a greater amount of subcutaneous fat. In this layer lie both the internal and external saphenous veins. The internal saphenous runs along the inner edge of the tibia and passes up to the thigh behind the internal condyle. Close to the upper end of the tibia is a favorite place for large varicosities to form in this vein (Fig. 141). The vein is often double in the leg, the second branch being a little further back. This double occurrence of the internal saphenous is well shown in figure 141. The vein is accompanied, from the knee downward, by the long or internal saphenous nerve, being intimately related to it. The latter relation will explain the frequency of pain along this nerve in varicose veins, especially when inflamed. The vein and nerve are accompanied by many lymphatics, which empty into the inguinal lymph-nodes (Fig. 59). In lymphangitis following any infection of the foot or leg their course may be traced by a red line extending along the inner border of the leg. This internal saphenous vein returns the blood from the inner aspect of the back of the foot and inner and front aspects of the leg. The external or short saphenous also arises on the back of the foot (outer side), but passes behind the external malleolus along the middle or posterior aspect of the leg. Close to the knee it penetrates the fascia, and, passing between the two heads of the gastrocnemius, empties into the popliteal vein (Fig. 58).

Close below, and curving around the head of the fibula, the musculocutaneous or superficial peroneal nerve lies (Fig. 136). It is exposed to injury in the low application of a constrictor, or after fractures, as explained below. After such injury to this nerve, the patient is unable to raise the outer edge of the foot,—*i. e.*, abduct it,—on account of the paralysis of the peroneus longus and brevis muscles; and there is anesthesia of the dorsum of the foot and outer aspect of the leg (see Fig. 23).

**Back of Leg.**—The fascia of the back of the leg is a continuation of that of the anterior aspect and of the popliteal fascia. It is also adherent to the tibia and fibula and forms a compartment for the muscles of the calf. Through two septa which it sends inward these muscles are divided into superficial and deep layers. In the superficial lie the gastrocnemius and soleus, and in the deep layer the popliteus, the long flexors, and the tibialis posticus, as well as the posterior tibial vessels and nerves. This fascia is very thin above, but quite firm below (see Figs. 151 and 152). On account of the arrangement of the fascia on the


**Fig. 151.—Cross-section of right leg below tuberosities of tibia, looking upward.**

posterior and anterior aspects of the leg, the same conditions exist as in the upper extremity (forearm), where pus, after it has once penetrated the deep fascia, causes an intermuscular suppuration (phlegmon), which may travel quite rapidly between the muscles on account of the arrangement of the fascia. A large incision, and retracting the muscles so as to expose every portion of the infected area, will correct this rapid spread which the anatomy of the part favors.

The tendo Achillis, formed by the union of the gastrocnemius and soleus, is attached to the calcaneus. It is separated from it by a small bursa which may become inflamed, giving rise to a pain at the insertion of the tendon (Achillodynia).

The **posterior tibial artery,** accompanied by the nerve of the same name, lies between the superficial and deep layers of muscles. It lies quite deeply in the upper portion of the leg (see Fig. 151), but in the lower portion it becomes superficial, winding around the back of the internal malleolus to reach the plantar surface of the foot (Fig. 159). Its pulsation can be felt just behind the posterior border of the internal malleolus. Both the posterior tibial artery and nerve are sufficiently removed from the tendo Achillis that there is no danger of wounding these vessels in a tenotomy, especially if the foot is forcibly flexed (bent upward) to make the tendon prominent.

The **peroneal artery** runs along the outer aspect of this posterior surface; it is the largest branch of the posterior tibial (see Fig. 136). Both the posterior tibial and the peroneal arteries are accompanied by venæ comites, which may play a rôle, as do those accompanying the anterior tibial, in varicose conditions.

The tibia is readily accessible for operations along its entire internal surface. The fibula lies very deeply, except the head of the external malleolus. There is but a slight amount of motion in the upper joint between the tibia and fibula. At their lower ends both of these enter into the formation of the ankle-joint. The upper epiphysis of the tibia has been referred to in connection with the knee-joint.

**Fractures of the tibia and fibula** occur most frequently by direct violence, such as being run over, but they may occur by indirect violence, the foot or knee being fixed and the bones breaking at their weakest point, which is usually the point of greatest curvature; that is, about the middle. If the fracture is high up, it may communicate with the knee-joint; or the popliteal vessels and musculocutaneous (superficial peroneal) nerve may be involved, and there is usually more or less tearing of the lateral ligaments of the joint. This is especially true of fractures through one or both tuberosities of the tibia. The most fre-

quent seat of fracture of the tibia and fibula is about the junction of the middle and lower thirds of the leg. The line of fracture is usually oblique, and, on account of the close proximity of the skin to the internal surface of the tibia, the fracture is often compound.

Separations of the upper or lower epiphyses of the tibia are rare (see Fig. 116). There is usually considerable lateral displacement in the fractures of the shaft of the tibia and fibula (see Fig. 153). The swelling of the leg may be so great as to hide the point of fracture. It is necessary at times to wait a week or longer (without the use of the $x$-ray) to determine the extent of the injury. A fracture of either bone of the leg may occur alone. At the lower end of the tibia and fibula injury is often accompanied by hemorrhage into the ankle-joint, and by tearing of either the internal or external lateral ligaments of this joint. These fractures close to the ankle are usually produced indirectly, by forcible pronation or supination of the foot or by sudden rotation. This typical fracture of the ankle is called a Pott's fracture (see Fig. 155), and in it various combinations can occur. The most frequent is a tearing-off of the tip of, or the entire internal malleolus, with laceration of the external lateral ligament; or there may be a fracture just above the external malleolus alone, with tearing of the internal lateral ligament or lastly both bones are broken above the malleoli. In the former case there has been forcible abduction of the foot; in the latter, forcible adduction. These injuries are usually accompanied by more or less displacement inward or outward of the foot, varying with the extent of injury to the internal or external malleolus respectively.

In the treatment of such fractures it must not be forgotten that the shaft of the tibia normally arches slightly forward, while that of the fibula arches slightly backward. The great tendency in the adjustment of such fractures is to forget this fact, so that the foot is pulled upward too much, resulting in a backward curving of the shaft of the tibia, instead of a slightly forward curve. At the same time, unless the axis of the limb is kept strictly in view (see Fig. 134), the result will be an inward or outward displacement of the foot upon the leg. This **axis of the leg** is represented by a line drawn through the middle of the patella directly downward, midway between the malleoli (see Fig. 134), and the continuation of this line to the space between the great and second toes. Care should also be taken, in adjusting a fracture of the leg, to keep the foot at right angles to the leg, because of a great tendency to the pes equinus position.

The tibia can be best measured (see Fig. 134) from the upper border of the internal tuberosity to the lower edge of the internal malleolus.


Fig. 152.—Cross-section of leg just above malleoli.

Fig. 153.—Fracture of both bones of leg at middle third. (From $x$-ray picture.)

The measurement of the entire lower extremity is shown in figure 133. It is the distance from the lower border of the internal malleolus through the middle of the patella to the anterior superior spine of the ilium.

## The Foot.

We speak of the upper aspect of the foot as the dorsum and of the lower aspect as the plantar surface. The dorsum is to a great extent convex, the convexity being upward; the plantar surface is concave. In stepping upon the foot only the heads of the metatarsal bones, especially those of the great and little toes, and the heel touch the ground under normal conditions. In many, however, there is a slight amount of pressure upon the outer border of the plantar surface, in addition. The remainder of the plantar surface is concave, the concavity looking downward, forming the arch of the foot. The relation of this arch to flat-foot will be referred to below.

**Dorsum.**—The skin of the dorsum of the foot resembles that of the dorsum of the hand. It is thin and elastic, and beneath it and the underlying fascia there is a loose connective-tissue layer in which the superficial veins, lymphatics, and nerves lie. Hence, as in the dorsum of the hand, edema is more marked on this surface than on the plantar surface, and infection, as in all loose connective-tissue layers, spreads more rapidly. The superficial veins can be seen through the skin, forming a network called the arcus venosus dorsalis (Figs. 141 and 158). Along the inner border of the foot these veins empty into the internal saphenous; along the outer border, into the external or short saphenous.

The internal saphenous passes upward from the foot, lying in front of the internal malleolus, and the external saphenous behind the external malleolus. Where these veins begin are favorite places for the formation of varicose ulcers. Over the dorsum of the foot one notices two depressions, one between the internal malleolus and the prominent tendon of the tibialis anticus, and the other between the external malleolus and the tendons of the extensor longus digitorum. These are the **most accessible portions of the ankle-joint,** and in case of fluid in this joint these depressions disappear. Aspiration of the joint can be best performed in the depression to the inner side of the internal malleolus (Fig. 158).

The fascia covering the dorsum of the foot is a continuation of that of the anterior aspect of the leg. It is continuous with that of the plantar fascia along the sides of the foot. It is thinner and far more elastic than

the latter, so that pus is not held under such great tension as on the plantar surface.

Between the internal and external malleoli, on the front of the foot, there are three important **tendon-sheaths,** the tendons of which can be distinctly felt through the skin here. These sheaths are that (see Fig. 135) of the tibialis anticus, which begins above the ankle-joint and passes through both portions of the annular ligament to end below the lower; that of the extensor longus hallucis (see Fig. 135), which begins just above the lower portion of the annular ligament and passes through a compartment of the latter, to end about the level of the scaphoid bone; the third tendon-sheath on the front of the foot is that of the extensor longus digitorum, which begins about three-fourths of an inch above the ankle-joint and extends about two inches along the dorsum of the foot. Between the external malleolus and the heel lie the peroneal tendons, surrounded by a common tendon-sheath (see Fig. 137), which extends from 1 to 1½ inches above the joint to the middle of the outer border of the foot. On the inner side of the dorsum of the foot, between the internal malleolus and the calcaneus, lie the tendons of the tibialis posticus (most internally), the flexor longus digitorum and the flexor longus hallucis. Each one of these is surrounded by a separate tendon-sheath. It is important to remember the location of these tendons, and especially of the tendon-sheaths (see Fig. 134). Inflammation of the latter is not uncommon, being both acute and chronic, and unless their position is remembered, the condition is often diagnosed as disease of the ankle-joint proper. A chronic inflammation of the tendon-sheaths of the peroneal and tibial tendons is not uncommon in flat-foot, giving rise to swellings on the inner and outer sides of the ankle. Between the internal malleolus and the calcaneus, accompanying the tendons here, lies the posterior tibial artery, which passes to the plantar surface of the foot. Its pulsation can be distinctly felt here. The artery, which supplies the dorsum of the foot, is a continuation of the anterior tibial artery, which, as was stated on page 471, becomes quite superficial at the lower third of the leg (Figs. 138 and 152). It passes beneath the annular ligament, becoming the dorsalis pedis artery, the main artery passing to the inner side of the head of the first metatarsal bone and giving off a transverse branch which runs to the outer border of the foot, and which, in turn, sends off digital interosseous branches for each toe, similar to the blood supply of the hand. The lymphatics of the dorsum of the foot along its outer border empty into the popliteal glands. Those along the inner border, accompanying the saphenous vein, empty into the inguinal nodes (Fig. 50). The nerve-supply of the skin is derived from the musculocutaneous superficial

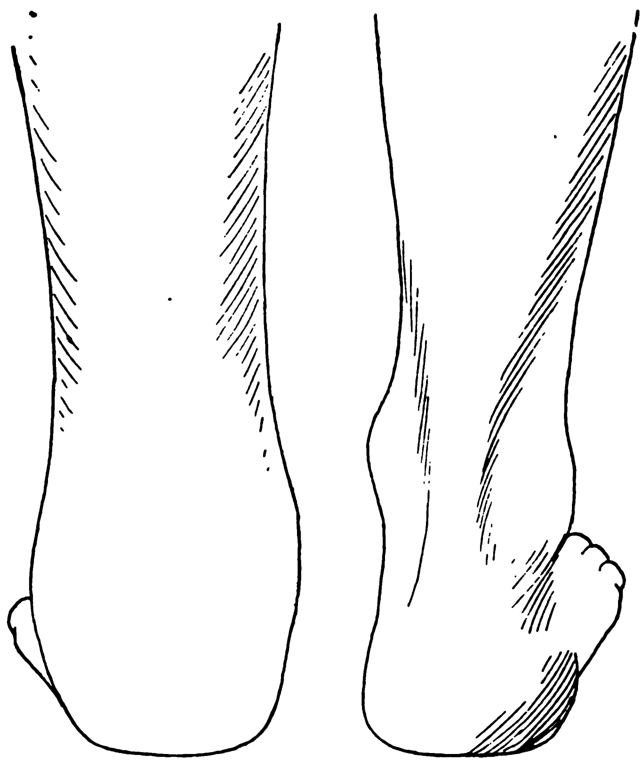

Fig. 154.—Outlines of normal ankle shown on the right, and of characteristic obliteration of depressions on either side of the tendo-Achillis which occurs in severe sprains of the ankle-joint, with or without fracture of either bone of the leg, of fracture of the tarsal bone.


Fig. 155.—Fracture of lower ends of tibia and fibula (Pott's Fracture). From x-ray picture.)

peroneal) over the greater portion of the dorsum, the inner border being supplied by the internal saphenous and the outer border by the external saphenous. The termination of the anterior tibial nerve accompanies the dorsalis pedis artery and supplies the skin of the outer side of the great toe, as well as the short extensors of the toes (Fig. 23).

**Plantar Surface.**—On the plantar surface of the foot there is a distinct concavity, referred to above. When this concavity or arch is absent, the deformity is known as *flat-foot.* When this is of long standing or congenital, it may give rise to no symptoms; but if acquired,—as frequently happens in those who are obliged to be on their feet a great deal, like waiters, etc.,—the condition becomes quite painful, and is often mistaken for rheumatism. A tracing of the sole of the foot made upon a blackened surface readily shows that the person uses a greater area to support his weight than is normal.

The skin of the sole of the foot is much firmer and less elastic than that of the dorsum. It is very firm over the points of support (heads of metatarsal bones, outer border of foot, and heel), but thinner elsewhere. Beneath it, and binding it to the firm plantar fasciæ, are many strong bundles of connective tissue, the relation of this connective tissue and of the fat which it holds in its interstices being analogous to the condition found on the palmar surface of the hand. Infection rapidly spreads from the surface of the skin toward the deeper structures along the lymphatics which accompany this connective tissue.

The **lymphatic and nerve-supply** of the skin of the sole (plantar surface) is exceedingly rich. The lymphatics, like those of the dorsum, empty respectively into the popliteal (outer border of sole) and inguinal nodes (inner border of sole) (see Figs. 59 and 60). The nerves are derived from the posterior tibial nerve. The internal plantar supplies the inner portion of the sole of the foot (see Fig. 159) and corresponds to the median nerve in the hand; the external plantar supplies the outer portion of the sole of the foot and corresponds to the ulnar nerve of the hand. Be tween the skin and the fascia are several **bursæ** which are of more or less importance. There is one over the outer aspect of the head of the metatarsal bone which may inflame (bunion), and not infrequently communicates with the metatarso-phalangeal joint of the great toe, especially when the latter is deformed (hallux valgus). There is also a bursa over the heel and one over the under surface of the heads of the first and fifth metatarsal bones. Over the head of the first metatarsal bone occasionally an ulcerative condition exists, due to a lesion of the trophic nerves, especially indicative of tabes, known as perforating ulcer of the foot.

The plantar fascia resembles the palmar fascia of the hand. It is

very tough, begins over the heel, and consists of a central portion which sends prolongations to the base of each toe, and of two lateral portions, which bind the central portion to the inner and outer borders of the foot. It divides the muscles of the sole of the foot into three compartments: Those of the big toe on the inside, those of the flexors of the other toes and lumbricales in the middle, and those of the little toe on the outer side. When suppuration once begins beneath this plantar fascia, it resembles that in the hand, in respect to the fact that it is under great tension and causes severe pain.

The **tendon-sheaths** of the plantar surface of the foot are not as complex as those of the palmar surface of the hand and do not play as great a rôle in the transmission of infection. Each flexor tendon is accompanied by a tendon-sheath which extends from the tip of the toe to about the head of the respective metatarsal bones, surrounding both the short and the long flexors. The tendon-sheaths referred to above, on the inner and outer aspects of the ankle, also extend to about the middle of the foot (peroneal and tibial tendons) (Fig. 158).

The **blood-supply** of the sole of the foot is derived from the continuation of the posterior tibial artery. The latter divides, like the posterior tibial nerve, into internal and external plantar branch. They begin just after the artery passes to the sole of the foot, *i. e.*, close to the internal malleolus (Fig. 159). The internal plantar is the smaller of the two. It supplies the inner border of the foot, uniting over the head of the first metatarsal bone with the plantar digital branch of the dorsalis pedis, to be distributed to the inner side of the great toe. The external plantar runs forward to the inner side of the base of the little toe, and turns abruptly inward to form the plantar arch, supplying the skin and giving off branches which supply the toes (digital branches). It will thus be seen that the blood-supply, both venous and arterial, is somewhat analogous to that of the hands and fingers, but the veins must travel a longer distance to the center of the venous system (heart) than in the upper extremity, and this favors stagnation of blood; so that freezing of the toes is perhaps a little more frequent than that of the fingers.

**Ankle-joints and Joints of the Foot.**—The ankle-joint (talocrural) is formed by the astragalus and the adjacent articular surfaces of the tibia and fibula (Fig. 150). It permits of movements only in two directions—sinking of the foot, or extension, and raising of the foot, or flexion. The excursion from extreme flexion to extreme extension is about 70 degrees. Flexion can be carried out over about 20 degrees (see Fig. 137) and extension over 45 degrees. Further extension or flexion is interfered with by the strong ligaments on the anterior aspect of

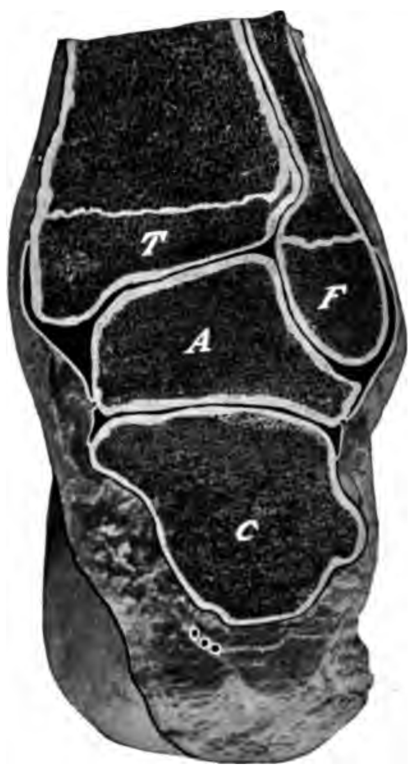


Fig. 156.—Coronal section of ankle-joint. T, Tibia. The letter is placed in the epiphysis; above it is seen the epiphyseal cartilage and the diaphysis. F, Fibula. This letter is also placed in the epiphysis. A, Astragalus. Between these three bones, tibia, fibula, and astragalus, the cavity of the ankle-joint is shown in black. C, Calcaneus. Between it and the astragalus above is seen the talo-calcaneal articulation.


Fig. 157.—Horizontal section of foot. T, Lower end of inner malleolus of tibia. C, Calcaneus. A, Astragalus (between A and C observe the talo-calcaneal joint). CU, Cuboid. S, Scaphoid, only a portion of which is seen. IC, Internal cuneiform. M, Metatarsal bones. 2, External cuneiform bone.

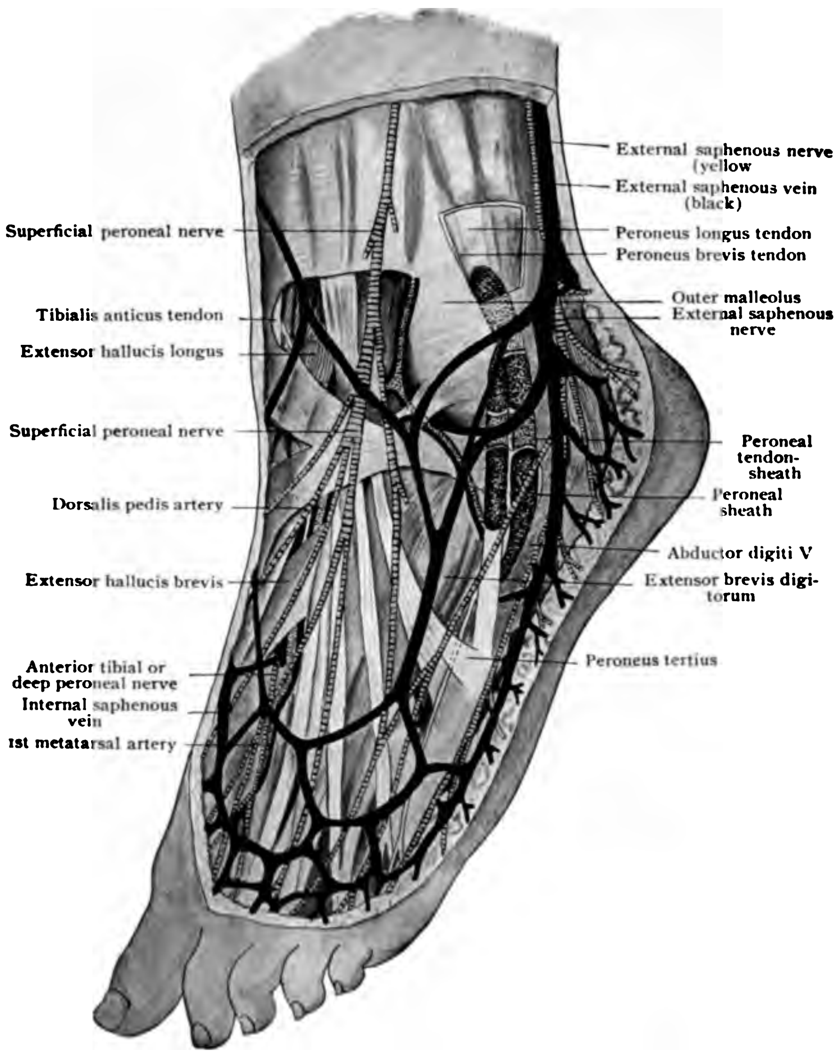


Fig. 158.—Dissection of dorsum of foot: arteries, dotted; nerves shown in yellow—veins black (Frohse).


Fig. 159.—Dissection of plantar surface (sole) of foot (Henle): nerves black; arteries hatched outline.

the joint, by the posterior ligaments and the tendo Achillis respectively. The outer malleolus extends further downward than the inner. A reference to figures 156 and 157 will show the relation of the three bones which form the ankle-joint to each other.

The anterior ligament of the ankle is the weakest of all; swelling in the joint itself first appears here and in front and behind the malleoli (see Fig. 134). The posterior, external and internal lateral ligament are very powerful; hence dislocation of the ankle-joint is either forward or backward, the former being somewhat more frequent. In spite of the strong character of the internal and external ligaments, they may be torn, either in part or as a whole, the milder forms giving rise to a **sprain,** as it is called, from which recovery is rapid. When almost an entire ligament is torn, there is an abnormal lateral movement at the ankle which persists for a long period.

The **capsule of the ankle-joint** is attached to the tibia and fibula just above the articular surface in front, but between the two bones it extends a short distance upward (Fig. 156). The fact that it is quite close to the skin on either side of the extensor and tibialis anticus tendons in front of the joint was referred to above.

The epiphyseal cartilages (see Figs. 116 and 156) lie close to the capsule of the joint. In Pott's fracture (see page 476) the articular surface of the tibia and fibula, and at times that of the astragalus, may be involved. Fractures of the astragalus and the calcaneus—so called compression fractures—may occur without injury to the tibia and the fibula, as a result of falling from a great height directly upon the sole of the foot.

The **intertarsal joints** (see Fig. 159) form a very complex arrangement with a view to compactness and strength, the relation of the tarsal bones being far more intricate than that of the carpal bones. There is usually movement in all of these joints simultaneously. There is one joint between the astragalus and calcaneus (talo-calcaneal) which is situated on the inferior facet of the body of the astragalus, and a corresponding facet on the anterior aspect of the os calcis. A second joint is that between the astragalus, calcaneus, and scaphoid. This is one of the most important. A third joint is that between the calcaneus and cuboid; a fourth is between the astragalus and scaphoid; a fifth between the calcaneus and cuboid; a sixth between the scaphoid and cuneiform; a seventh between the contiguous surfaces of the cuneiform bones; and an eighth between the cuboid and cuneiform. The only places where there are distinct synovial membranes are between the astragalus and calcaneus, between the astragalus and calcaneus and cuboid, and between the scaphoid and cuneiform bones. The **move-**

ments in all of these joints consist in adduction (that is, turning inward of the end of the foot) and abduction (turning outward of the end of the foot). Adduction is always accompanied by supination and abduction by pronation; that is, whenever the foot is turned inward, its inner edge is usually raised and the outer lowered (supination); whenever the foot is turned outward, the outer edge is raised and the inner lowered (pronation). These movements of the foot are carried out to a great extent by the peroneal and tibial muscles, the former (peronei) being abductors and pronators, the latter (tibial) being adductors and supinators.

The range of movement in the intertarsal joints is approximately 42 degrees. The short joints of the foot are the metatarso-phalangeal and the interphalangeal. Dislocations and fractures of the metatarsal and the phalangeal bones are very rare, although they may occur. Acquired deformities of the interphalangeal joints occur in the form of dislocations of the phalanges known as hammer-toe.

## Nerve-supply of Lower Extremities and Effects of Paralysis of Individual Nerves.

Paralysis of the branches of the sacral and lumbar plexuses, which supply the lower extremity, may occur as a result of myelitis, or of any condition which causes pressure upon the nerves of the cauda equina, either before or after leaving the spinal canal (see Figs. 160 and 161). Paralysis of the individual nerves, however, in the lower extremity, as a result of spinal paralysis of children (anterior poliomyelitis), occurs more frequently than in the upper extremity.

| NERVES. | SUPPLY. | RESULTS OF PARALYSIS. |
|---|---|---|
| Anterior Crural. | Iliopsoas and Quadriceps muscles. | 1. Impossible to flex hip, or extend thigh. 2. Anesthesia of lower two-thirds of thigh, of anterior region of knee, and along inner side of leg to inner malleolus (internal saphenous) and inner side of foot and great toe (see Fig. 23). |
| Obturator. | Adductors, Gracilis, and Obturator externus; also skin of lower two-thirds of inner side of thigh. | 1. Anesthesia of skin area (see Fig. 23). 2. Impossible to adduct thigh. 3. Flexion of knee and inward rotation of tibia partly lost (Gracilis). 4. External rotation of hip diminished (Obturator externus). This nerve may be paralyzed as a result of pressure of fetal head, or by an obturator hernia. |
| Gluteal | Glutei, Pyriformis, Tensor fasciæ latæ, Obturator internus, and Gemelli. | 1. Impossible to rotate lower extremity outward (paralysis of external rotators). 2. Impossible to extend hip (glutei). 3. Anesthesia of skin of gluteal region. |

| Nerves. | Supply. | Results of Paralysis. |
|---|---|---|
| Peroneal. | Tibialis anticus, Extensor communis digitorum longus et brevis, Extensor hallucis longus et brevis, and the three Peronei muscles; also supplies skin of outer and posterior aspect of leg and dorsum of foot, except inner and outer edges of latter. | 1. Cannot flex foot. 2. The end of the foot droops in walking, due to paralysis of the tibialis anticus and the Peronei. 3. Cannot extend the toes, due to paralysis of the Extensors. 4. Impossible to adduct foot and raise inner edge. This is still possible to a slight degree if the Tibialis posticus, supplied by the tibial nerve, is preserved. 5. Impossible to abduct foot and to raise outer edge of same. This impossibility to adduct or abduct foot, as the case may be, results in paralytic pes valgus, equino varus, and calcaneus. 6, Anesthesia of the skin supplied by this nerve. |
| Tibial.. | Superficial and deep muscles of calf, Gastrocnemius, Soleus, Plantar, Popliteus, Tibialis posticus, Flexor digitorum et Hallucis longus, and small muscles on plantar surface; also skin of plantar surface and heel. | 1. Impossible to extend foot (Gastrocnemius, Soleus, Plantar, Popliteus, and Tibialis posticus). 2. Impossible to flex toes. 3. Lateral movements of foot lost on account of paralysis of Interossei, etc. |

# THE SPINE.

**Examination of the Spine in the Living Adult.**

1. With the patient standing with heels together, observe the depression in the middle of the back. It is called "the spinal furrow." It is somewhat noticeable in the cervical region, and most marked in the lower dorsal and the upper lumbar regions. It corresponds to the space between the trapezii in the cervical region, and to a similar groove between the larger erector spinæ muscles in the dorsal and lumbar regions.

2. Palpate the spines of as many vertebræ as possible, and mark the same with a blue pencil. In the cervical region only the spinous processes of the sixth and seventh vertebræ can be distinctly felt. The latter (vertebra prominens) is usually taken as the starting-point in counting the dorsal and lumbar vertebræ.

In the dorsal and lumbar regions the spines are quite distinct. Owing to their obliquity in the dorsal region, each spine lies opposite the body of the underlying vertebra. For example, the spine of the sixth dorsal corresponds in position to the body of the seventh.

In the lumbar region each spine lies opposite the body of the corresponding vertebra.

The spine of the fifth lumbar vertebra is very short, and instead of a prominence there is a slight depression.

This fifth lumbar spine is used in the measurement of one of the diameters of the female pelvis—the external conjugate. The measurement is made with the aid of a pelvimeter from the above depression to the upper border of the symphysis pubis, and is 20¼ centimeters (8½ inches) under normal conditions (conjugate externa, or external conjugate).

Palpate the rudimentary spines of the first three sacral vertebræ, and also palpate the coccyx.

3. Mark out the two posterior superior spinous processes of the ilium. They are on a line with the third sacral spine (see Fig. 69). They form the guide to the sacro-iliac joints, which lie below them.

4. Draw a line (with the aid of a steel tape-measure) joining the highest points of the two crests of the ilia. This line passes through the spine of the fourth lumbar vertebra in the median line. These landmarks are frequently employed (see Fig. 69) to locate the fourth lumbar spine prior to the operation of lumbar puncture of the dural

In children the needle can be inserted just beneath the fourth lumbar spine, and in adults ½ to ¾ of an inch on either side. This method has been used for diagnostic purposes by withdrawing some of the cerebrospinal fluid for examination. The same route has been used for the injection of cocain and eucain solutions for spinal anesthesia.

5. Mark with a cross the point of termination of the spinal cord (see Fig. 69). The cord ends at the lower border of the body of the first lumbar vertebra in adults. It corresponds fairly accurately on the surface to the lower border of the corresponding (first lumbar) spinous process. In children the termination of the spinal cord is at the lower border of the body of the third lumbar vertebra.

6. Mark the point of termination of the dural sac with a cross. It is opposite the body of the third sacral vertebra, and can be best found by drawing a line between the two posterior superior spinous processes (see Fig. 69).

7. Observe the contour (seen from the side) of the normal adult spine. In the cervical region the vertebral column is convex forward (lordosis), so that the bodies of the second to the sixth vertebræ can be readily felt through the mouth. In the dorsal region there is a slight backward convexity (kyphosis), and in the lumbar region a second compensatory convex forward curve (lordosis). In thin individuals, especially in women with lax abdominal walls, this normal lordosis is so marked that the bodies of the lumbar vertebræ can be distinctly felt through the abdominal walls. The pulsation of the abdominal aorta under these conditions is so distinct as to be associated in the mind of the beginner with the possibility of aneurism of that vessel.

8. Observe the movements of the spinal column. They are flexion, extension, and lateral movement or rotation. Flexion and extension can be observed to be most marked from the atlas to the third dorsal vertebra (cervical), and again from the tenth dorsal to the fifth lumbar vertebra (lumbar) (see Fig. 168). There is but little motion in the dorsal region (third to tenth dorsal). Pott's disease (Fig. 164) causes early fixation of the more movable portions of the spinal column. This will be referred to again on page 507. Lateral motion, in the strict sense, can be but slight, owing to the small space given by the compression of the intervertebral discs. Lateral movements are always accompanied by more or less rotation of the bodies of the vertebræ. This movement, like extension and flexion, is also most marked in the cervical and lumbar regions. The rotation of the bodies may become more or less fixed under pathologic conditions, resulting in the disease known as

lateral curvature or scoliosis (see Fig. 167), which will be referred to on page 511.

In children the spine is far more flexible than in adults. There is only one curve, a backward one, and this embraces the entire spinal column.

## The Spine in a Clinical Sense.

From a clinical standpoint the spine may be considered as an elastic stick or staff which is composed of a number of separate parts, the vertebræ. The vertebræ are so firmly bound together through the medium of the intervertebral discs and ligaments that they form an elastic whole or entity, and may be so considered clinically.

The vertebræ articulate with each other in two ways:

(*a*) At their bodies through the interposition of a fibrocartilaginous disc.

(*b*) The interneural articulations. These are the joints between the articular processes of adjacent vertebræ. There is one joint on each side of the vertebra. It has a firm capsule and a synovial membrane.

The bodies are joined to those above and below them by the firm anterior and posterior ligaments, which are attached along the entire length of the spine, thus giving it the functions of a continuous structure.

In addition to these strong ligaments binding the bodies, there are powerful ligaments connecting the laminæ, spines, transverse and articular processes.

**The functions of the spine are:**

(*a*) To support the head and trunk.

(*b*) To afford a fixed point for the movements of the head and of the upper and lower extremities.

(*c*) To form a protecting canal for the spinal cord and its membranes permitting the spinal nerves to emerge at the various levels through the intervertebral foramina (see Fig. 149).

## Normal Contour or Form of the Spine.

In adults the spinal column has three curves, as follows:

(*a*) A forward curve in the cervical region (lordosis).

(*b*) Backward curve in the dorsal region (kyphosis).

(*c*) Forward curve in the lumbar region (lordosis).

It may be well to state at this point that the term *kyphosis* is applied to a curve in the spine the convexity of which is directed backward, that

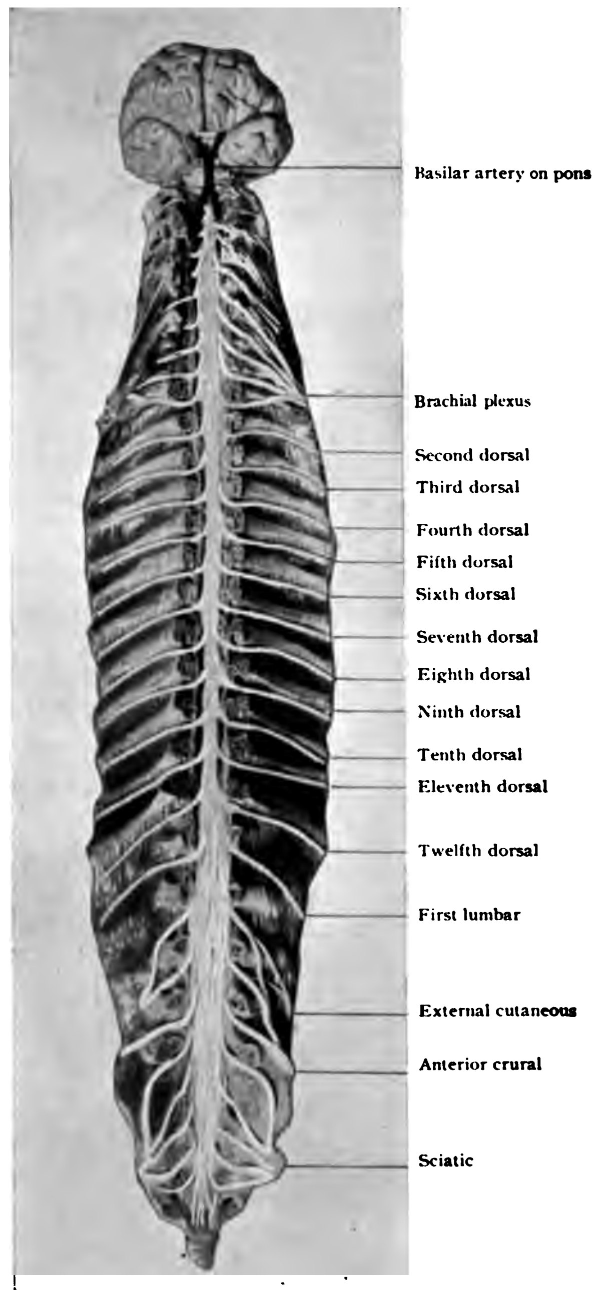


Fig. 160.—View of brain and spinal cord *in situ*.

the term *lordosis* is applied to a curve the convexity of which is directed forward, and that a curve of the spine toward either the left or the right of the median line of the body is called a *scoliosis* or lateral curvature.

These curves in the normal adult spine arise in this manner: At birth the spine is perfectly straight. When the infant begins to sit up, the weight of the head and shoulders and the forward traction on the part of the viscera cause the development of a backward curve or kyphosis, which extends over the whole spine. With the effort of the child to hold up its head the cervical portion of the spine gradually bends forward (lordosis). The third curve appears when the child begins to walk. In order to maintain the upright position, the child uses its back and gluteal muscles. At the same time the pelvis is inclined downward, thus throwing the center of gravity of the body farther back. In order to compensate for this the lumbar portion of the spine is bent forward, resulting in the above-referred-to lordosis of that region. These curves are not well marked until the seventh year, and can be entirely obliterated by traction upon the child's head. In adults, however, they are practically permanent. A normal individual shows, when viewed from the side, a physiologic or **normal contour,** which is of a wave-like character when standing erect, being slightly convex forward in the cervical, distinctly convex backward in the dorsal, and again convex forward in the lumbar region. We thus see that the true curve of the spine is a kyphosis or backward curve, as exemplified in the dorsal region in the adult, and that the cervical and lumbar forward curves (lordosis) are compensatory. When a person bends forward, the normal contour is a continuous convexity backward, the compensatory curves being apparently obliterated (see Fig. 168).

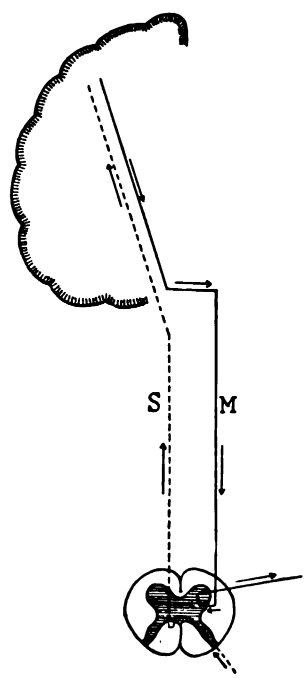


Fig. 161.—Diagram of motor and sensory tracts in spinal cord. M, Motor nerve and tract. S, Sensory nerve and tract.

A change in the normal contour is of as great value in the diagnosis of certain diseases of the spine as the pain and limitation of the normal mobility, which will be referred to shortly. Such a change in the normal contour may arise gradually and not be considered as a

pathologic condition. For example, a person may have a backward curve (kyphosis) as the result of occupation, especially those who must bend forward in their work. Again, one observes a distinct kyphosis in elderly persons, as the result of the atrophy of the intervertebral cartilages or discs, which form nearly one-fourth of the entire length of the spine.

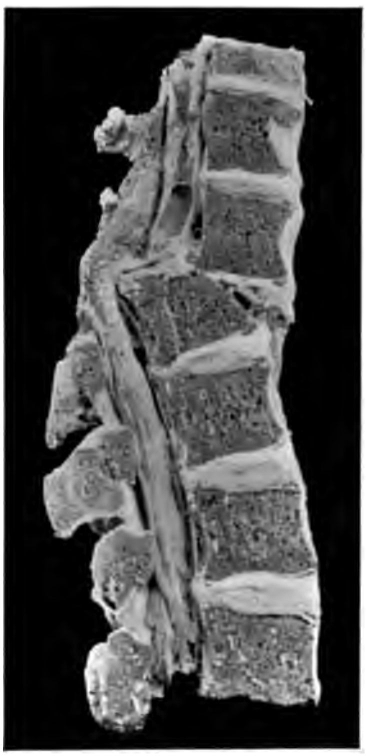

Fig. 162.—Fracture-dislocation, showing crushing of the cord (Guy's Hospital Museum).

Under pathologic causes which can change the normal contour the following may be mentioned:

(*a*) Rachitis (Rickets).—This disease causes the normal kyphosis which is present just before the child walks (see above) to be exaggerated.

(*b*) Tuberculosis (Pott's disease).—This causes (see page 512) an early change in the contour. In some it causes a sharp angular deformity with convexity backward, in others the backward curve (gibbus or kyphosis) extends over a considerable portion of the spine (see Fig. 164). It is usually compensated by curves in the opposite direction in the nonaffected regions.

(*c*) Arthritis deformans or osteoarthritis of the spine.—This causes a backward curve involving the entire spine.

(*d*) Infectious diseases (Typhoid, Gonorrhea, Scarlatina, etc.).—Cause a backward curve which may or may not become permanent.

(*e*) Traumatism.—A marked change in contour may result suddenly, as after a fracture-dislocation of the vertebræ, or it can develop gradually from a softening of the bone after an injury. The resulting change may be either an abnormal forward or backward curve (Fig. 162).

(*f*) In certain neuroses.—In hysteria, and in simple and traumatic neurasthenia, one frequently observes the development of a backward curve, especially in the dorsal region, through the weakness of the back muscles, and a drooping forward of the shoulders. This con-

(*h*) In hip-joint disease.—This causes in the early stages a considerable degree of forward curve (lordosis) in the lumbar region which is compensatory in nature. A similar curve appears in cases of congenital dislocation of the hip.

## Normal Movements of the Spine.

As was stated above, the vertebræ articulate with each other through a median (intervertebral discs uniting bodies of vertebræ) and two lateral (articular processes) articulations. Although the ligaments which serve to strengthen these joints and which bind the arches to each other are very powerful and serve to maintain the body in the erect position, they permit of a considerable degree of flexibility of the spine. The muscles which serve to carry out these movements are those attached to the front and back of the cervical vertebræ, those which form the great mass of back muscles (attached to the dorsal and lumbar vertebræ), as well as those lying on the anterior surface of the lumbar vertebræ (psoas).

These **normal movements** are:

(*a*) Flexion or bending forward of the spine.
(*b*) Extension or bending backward of the spine.
(*c*) Lateral flexion or bending either to the right or left.
(*d*) Rotation or revolving the spine upon its vertical axis.

Flexion is most marked in the cervical and lumbar regions. The dorsal region permits of but little flexion owing to the thinness of the intervertebral discs and the imbrication of the laminæ and spines (see Fig. 25).

Extension is most marked in the same regions as flexion.

Lateral flexion is possible only in a slight degree in the lumbar region. In other places it is possible only through more or less rotation of the vertebræ.

Rotation is possible only in the cervical and dorsal regions.

All of the movements of the spine are best carried out in the cervical and dorsal regions. The point of greatest mobility is from the eleventh dorsal to the first lumbar vertebra.

The normal range of movements of the spine may vary greatly with different individuals. It is limited—*i. e.*, decreased—in many of the diseases which were mentioned above as causing a change in the normal contour. Any condition which will cause an inflammation of the osseous or ligamentous structures of the spine will cause an early fixa-

to the fact that the spines are not of equal length or direction. Those of the neck are very short, those of the dorsal region very long and oblique, while those of the lumbar region are short and vertical. Under normal conditions there may be a slight lateral deviation of the spines of the vertebræ in the dorsal region, with compensatory curves, just as in a scoliosis above and below the curvature. This normal deviation is due perhaps to the greater development of the muscles of one side of the body in right-handed individuals.

**Abnormal Lateral Deviations of the Spine** (**Scoliosis**).—These are either primary or secondary. If primary, it is not due to a disease of the spine, but it is a deformity, most frequently the result of a faulty attitude at school, etc., in which the vertebræ attempt by a change in form to accommodate themselves to the attitude. If secondary, it occurs after any disease which interferes with the equal use of the limbs, such as sciatica or shortening of the limbs, or it may occur in wry-neck (torticollis). It can occur after an empyema with extensive resection of the ribs, or after poliomyelitis anterior as the result of the weakness or paralysis of the back muscles.

**Primary scoliosis** is the more frequent. It is not only a lateral but also a rotary deformity, the vertebræ being not only compressed but also rotated upon each other. When the patient stands up, the lateral deviation is most marked (see Fig. 166). When he bends forward, the rotary deformity is more apparent. At the same time there is twisting of the contents of the thorax and abdomen, to which reference was made in the section upon the thorax. The organs accommodate themselves to this condition and it must be borne in mind in examining such patients. Owing to the marked displacements of the thoracic and abdominal viscera in some cases, one has no guide other than to remember that the greatest change in position is on the side of the greatest convexity.

**Abnormal Antero-posterior Deviations of the Spine.**—These may occur either as primary or secondary. The former are far more frequent. The most frequent cause of such primary deformity is **Pott's disease** or tuberculosis of the spine.

### Tuberculosis of the Spine. (Pott's Disease.)

This disease may develop at any period, but is most frequent between the ages of three and ten. It affects the bodies of the vertebræ, almost invariably causing a breaking-down of the bone. If this occurs rapidly, there is usually formation of pus. If it occurs more slowly, the granulation tissue is replaced by fibrous tissue without the formation of pus.

Owing to the fact that the disease affects the bodies, these yield under the static pressure and sink in, giving rise to the characteristic backward deformity. The disease is most frequent at the point of greatest mobility of the spine (dorso-lumbar junction) and the deformity is most frequent here. It may be quite sharp or may involve the entire dorsal region (Fig. 164). The pus usually migrates to the surface of the body. Its most typical course is to follow the sheath of the trapezius or sternomastoid in the neck. In the dorsal region it follows the course of the psoas to the fold of the groin, or it may appear between the

Fig. 166.—Scoliosis, showing principal curvature to right in dorsal region, and compensatory, in opposite direction, in lumbar and cervical regions. The prominence of the posterior portion of the thorax well marked on side of curvature. The difference in the contour of the chest also to be noted.

last rib and crest of the ilium, having penetrated the lumbar fascia. Pus from the lumbar region takes the same course as that of the dorsal. Such cold abscesses are often called gravitation abscesses. The tubercular inflammation may extend to the membranes of the spinal cord and cause a compression of the cord with resultant paralysis. Such a paralysis can also occur through direct compression of the cord by the vertebræ themselves, in the same manner as in a fracture (see Fig. 162.

The symptoms of tuberculosis can be readily understood if one recalls the normal contour and flexibility of the spine and the anatomic

Fig. 167.—Normal lordosis of spine. Note the slight forward curvature in lumbar region of a child lying in normal supine position.

Fig. 168.—Flexibility and normal contour of spine. Note the arch normally present when the spine is flexed. Both flexibility and normal contour disappear in Pott's disease.

fact that the spinal nerves pass out on either side of the body of the vertebra. Hence one would expect stiffness, change in contour (deformity), and pain (often referred to the ends of the corresponding nerves) as the principal symptoms.

## Congenital Defects of the Spine.

This condition is called **spina bifida** and is due to the imperfect closure of the epiblastic layer in the embryo from which the spinal cord and its membranes are formed. It may involve the entire medullary canal or only that portion corresponding to a single vertebra. If the latter, the deformity is most frequently in the lumbar or sacral region (see Fig. 163). It may be only a meningocele, involving only the membranes, or a myelomeningocele, embracing both cord and membranes.

## Injuries of the Spine.

These may be very slight (sprain or twisting) or very severe (fractures or dislocations). They may be partial, involving only a portion of the vertebra, or total, causing the complete destruction or dislocation of it. Injury to the vertebræ may be caused (*a*) by a direct blow, fracturing the arches (this is rare); (*b*) it may be the result of a fall upon the head or buttocks; or, lastly, (*c*) it follows forced flexion or extension of the spine, resulting in either a fracture or dislocation or both. In the cervical region a dislocation may occur without fracture, but in the other regions they are usually combined (Scudder). Not infrequently, either as the direct result of the pressure of fragments or from the pressure of a blood-clot (hematomyelia) in the spinal canal, paralysis results (see Fig. 162). A careful examination of the extent of motor and sensory paralysis, as well as the state of the reflexes, will enable one to judge fairly accurately as to the seat and extent of the lesion. When an injury is immediately followed by motor paralysis, anesthesia, and loss of reflexes, it is fair to assume that the cord has been crushed by the fragments. When such symptoms arise gradually, the outlook is more favorable because the pressure is due to a blood-clot (hematomyelia), which is usually absorbed with great improvement in symptoms.

## The Spinal Cord and its Membranes.

The spinal cord begins at the foramen magnum in the skull and extends to the lower border of the first lumbar vertebra (see Figs. 69 and 160) in adults. At its upper end it passes into the ***medulla oblongata***,

and at its lower end it tapers rapidly to a point—the *conus medullaris.* From the end of the latter a fine thread of tissue is continued downward to attach the spinal cord to the back of the coccyx. In children the cord ends at the third lumbar vertebra.

The spinal cord is amply protected from injury in the following manner:

(*a*) The cord is smaller in diameter even at its cervical and lumbar enlargements than the canal in which it lies.

(*b*) Its coverings separate it from the bones of the spine so as to diminish the effects of a jar or concussion of the same. The dura is not so closely attached to the bones of the spine as is the dura of the skull, because the vertebræ have an independent periosteum and are not dependent upon the dura for their nutrition, as was seen in the case of the bones of the skull. The dura is separated from them by a soft mass of fat and a considerable number of thin-walled spinal veins. The inner layer of the dura is smooth, as in the skull, and thus lessens friction. In the meshes of the pia-arachnoid there is, as in the brain, a large quantity of cerebrospinal fluid, which acts as a buffer in diminishing the effects of a jarring of the spine.

(*c*) The cord is not loosely suspended in the spinal canal, but, through the aid of the ligamenta denticulata, which pass from the cord to the inner surface of the dura (Fig. 33), and the spinal nerves, it is given great stability (see Fig. 160).

There are 31 pairs of spinal nerves, which arise at different levels of the cord. There are 8 cervical, 12 dorsal, 5 lumbar, and 6 coccygeal nerves (see Fig. 160). These have but little relation to the corresponding vertebræ, as will be seen in Fig. 160, owing to the fact that in the child the bones grow more rapidly than the cord, and thus the termination of the cord in the adult does not correspond to the end of the dural sac, which is at the third sacral vertebra (see Fig. 69). The cauda equina, which begins at the end of the cord, is therefore composed of lumbar, sacral, and coccygeal nerves, which lie opposite the lumbar vertebræ from the second downward. Hence an injury of the lumbar spine may not affect the cord at all and involve only the nerves of the cauda.

## Segments of the Spinal Cord.

Each pair of nerves is attached to the cord by a *ventral* and a *dorsal root.* The ventral is a motor nerve, and each fiber composing it is connected with a ganglion cell of the anterior horn, and may be called a motor neuron or entity. The dorsal branch is composed of sensory

fibers which have their lowermost trophic center in the spinal ganglia, and is then continued through the posterior horns of the cord into the posterior columns. Each sensory fiber may be called with its corresponding cell a sensory neuron (see Fig. 160).

Each section of the spinal cord in which a motor and a sensory nerve arises is called a **segment.** Every **spinal cord segment** possesses motor, sensory, and reflex functions, besides vasomotor, visceral, and trophic activities. The entire trunk and extremities receive their innervation from the corresponding segments. This is well shown in figures 23 and 80. There is no sign externally on the cord to mark the level of the segments. From a study, however, of the symptoms in any given case one can locate the lesion in a definite segment of the cord.

LOCALIZATION OF FUNCTIONS IN SEGMENTS OF SPINAL CORD.

(Modified from Edinger and Starr.)

| SEGMENT. | MUSCLE. | AREA OF CUTANEOUS SENSATION. | REFLEXES. |
|---|---|---|---|
| 2d and 3d cervical | Sternomastoid. Trapezius. Scaleni and neck muscles. Diaphragm. | Neck and occipital region. | |
| 4th cervical .... | Lev. ang. scapulæ rhomboideus. Supra- and infra-spinatus. Deltoid. Supinator longus. Biceps. | Shoulder region. | Dilatation of pupil. |
| 5th cervical .... | Supinator brevis. Serratus magnus. Pectoralis major (clavic. portion). Teres minor. | Radial side of arm to insertion of deltoid. | Scapular reflex. Tendon reflexes of corresp. muscles. |
| 6th cervical..... | Pronators. Brachialis anticus. Triceps. Long extensors of hand and fingers. | Radial side of arm to middle line of middle finger. | Tendon reflexes of the corresp. muscles. |
| 7th cervical..... | Pect. major (costal portion). Latiss. dorsi. Teres major. Long flexors of fingers and hand. | Ulnar side of hand from middle line of ring to middle line of middle or third finger. | Periosteal reflexes of radius and ulna. Tendon reflexes of corresp. muscles. |
| 8th cervical..... | Extensor poll. longus et brevis. Small muscles of hand. | Ulnar side of hand to middle line of ring-finger. | Tendon reflexes of corr. muscles. |
| 1st dorsal...... | | Small area on ulnar side of arm and forearm. | Same. |

LOCALIZATION OF FUNCTIONS IN SEGMENTS OF SPINAL CORD.—(*Continued.*)

| SEGMENT. | MUSCLE. | AREA OF CUTANEOUS SENSATION. | REFLEXES. |
|---|---|---|---|
| 2d to 12th dorsal. | Muscles of back and abdomen. | Skin of thorax and abdomen and upper gluteal region. | Epigastric and abdominal reflexes. |
| 1st lumbar..... | Abdominal muscles. Iliopsoas. | Skin of pubic region and front of scrotum. | Cremaster reflex. |
| 2d lumbar...... | Sartorius. Hamstring muscles (flexors of knee). Quadriceps femoris. | Anterior and inner aspects of hip. Inner side of thigh and leg to malleolus. Inner side of foot outer side of hip. Lumbar region. | Patellar reflex. |
| 3d lumbar...... | Inward rotators of thigh. | | |
| 4th lumbar..... | Adductors of thigh. Glutei. | | Gluteal reflex. |
| 5th lumbar..... | Tibialis anticus. Calf muscles. Flexors of knee (?). External rotators of thigh. Flexors of foot (?). Extensors of toes. Peronei. | Back of hip, of thigh, outer side of leg and foot. Dorsum of foot. Back of thigh. Outer side of leg and foot. | |
| 1st and 2d sacral | Flexors of toes and foot. Small foot muscles. | | Plantar reflex. Tendo Achillis reflex. |
| 3d to 5th sacral. | Muscles of perineum | Skin of anus. Skin of perineum. Skin over sacrum. Skin over genitals. | Bladder and rectal reflexes. |

The above brackets show how the nuclei of the various nerves extend over one or more segments. In general, for each nerve there are one principal and one or more auxiliary segments.

On cross-section the spinal cord can be seen to be divided into anterior, lateral, and posterior columns. These constitute the white matter of the cord and are composed of fibers, which transmit motor impulses *from* the brain (see Fig. 160), sensory impulses *to* the brain, and other fibers, as will be explained. In the central portion of the cord lies the *gray matter*, in the form of the letter H, the anterior horns being wider than the posterior. The gray matter is composed of a very vascular neuroglia, of ganglion cells, and of non-medullated nerve-fibers. Every ganglion cell of the anterior horns serves as a trophic center for a corresponding axis-cylinder process, which passes to the motor nerve or root. The cells of the posterior horn probably have a similar function toward the sensory fibers, especially those of pain and temperature. The nerve entity which is composed of the ganglion

cell and nerve-fiber is called a **neuron.** As stated above, one can speak of a motor and of a sensory neuron. After destruction of its trophic cell, the neuron degenerates. After severing the nerve-fiber, the peripheral portion degenerates.

The **lower motor neuron** is composed of a cell of the anterior horn, with the fiber leading to the muscle (see Fig. 160). With this motor fiber, probably, the rami communicantes pass out of the cord to the sympathetic. The **upper motor neuron** is composed of the fibers of the pyramidal tracts, which carry impulses from the brain downward and have their trophic cells in the cerebral cortex. Both of these motor neurons degenerate *peripheral* to the seat of the lesion. When the lower motor neuron is affected, the corresponding muscle degenerates and shows the reaction of degeneration. When the upper motor neuron is affected, there is paralysis but no loss of reflexes, no atrophy or change in electrical reaction. The anterior pyramidal tract is mostly found in the cervical portion of the cord. The lateral pyramidal tracts cross in the pyramids (see Fig. 160).

The sensory fibers have their lowermost trophic center in the spinal ganglia. Some of these sensory fibers communicate with the motor cells in the anterior horn in an indirect manner, to form a **reflex arc.** Others form a communication with the cerebellum, while still others connect those of the two sides of the cord. The remainder of the fibers pass upward in the columns of Goll and Burdach. These seem to carry the sensation of pressure. The sensory paths degenerate in an upward direction. Similarly the cerebellar tracts, which probably have to do with co-ordination. The pain and temperature tracts seem to come into relation with the new neurons in the posterior horns and cross over to the opposite side and pass upward. The Brown-Séquard theory, which at first held that all of the sensory tracts crossed, now holds good only for pain and temperature. The nerves of tactile sense seem to cross in part only. The remainder of the tracts probably connect one portion of the spinal cord with the other.

As a result of the above knowledge, we are able in certain cases to determine at which level the lesion lies. In a central lesion there is no atrophy of the muscles, no disturbance of the reflex arc, and both nerves and muscles react to electrical stimulus in a normal manner. The reflexes are, if anything, slightly increased on account of the withdrawal of cerebral inhibition, resulting in a gradually developed spastic contracture (spastic spinal paralysis). When there is an affection of the anterior horn, the reflexes are lost, there is a flaccid paralysis, a fibrillary contraction of the muscles, reaction of degeneration, and

gradual loss of all reaction (poliomyelitis anterior). This may affect a large area or only individual nerves, as in infantile spinal paralysis. A lesion of the anterior roots has the same effects as the destruction of its ganglion cells. A lesion of the posterior columns through lack of muscular sensation leads to sensory ataxia; even the sense of touch is lost. The reflex arcs are not preserved. When the posterior roots are involved, all sensory stimuli are lost, as well as the reflexes (locomotor ataxia). Lack of muscular sense here causes sensory ataxia. Lesions of the posterior horns, especially close to the central canal, cause disturbances of pain and temperature sense (syringomyelia). Symptoms of irritation may occur, such as tonic and clonic convulsions in the motor areas, and of hyperesthesias. They seldom occur in affections within the cord, but more frequently in irritations of the root, especially of the sensory cornua; their appearance is of differential diagnostic value.

# INDEX

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